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SCIENTIFIC CULTURE.[1]

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YOU have come together this morning to begin various elementary courses of instruction in chemistry and mineralogy. As I have been informed, most of you are teachers by profession, and your chief object is to become acquainted with the experimental methods of teaching physical science, and to gain the advantages in your study which the large apparatus of this university is capable of affording. In all this I hope you will not be disappointed. You, as teachers, know perfectly well that success must depend, first of all, on your own efforts; but, since the methods of studying Nature are so different from those with which you are familiar in literary studies, I feel that the best service I can render, in this introductory address, is to state, as clearly as I can, the great objects which should be kept in view in the courses on which you are now entering.

By your very attendance on these courses you have given the strongest evidence of your appreciation of the value of chemical studies as a part of the system of education, and let me say, in the first place, that you have not overvalued their importance. The elementary principles and more conspicuous facts of chemistry are so intimately associated with the experience of every-day life, and find such important applications in the useful arts, that no man at the present day can be regarded as educated who is ignorant of them. Not to know why the fire burns, or how the sulphur-trade affects the industries of the world, will be regarded, by the generation of men among whom your pupils will have to win their places in society, as a greater mark of ignorance than a false quantity in Latin prosody or a solecism in grammar. Moreover, I need not tell you that physical science has become a great power in the world. Indeed, after religion, it is the

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greatest power of our modern civilization. Consider how much it has accomplished during the last century toward increasing the comforts and enlarging the intellectual vision of mankind. The railroad, the steamship, the electric telegraph, photography, gas-lights, petroleum-oils, coal-tar colors, chlorine-bleaching, anæsthesia, are a few of its recent material gifts to the world; and not only has it made one pair of hands to do the work of twenty, but it has so improved and facilitated the old industries that what were luxuries to the fathers of our republic have become necessities to our generation. And when, passing from these material fruits, you consider the purely intellectual triumphs of physical science, such as those which have been gained with the telescope, the microscope, and the spectroscope, you cannot wonder at the esteem in which these branches of study are held in this practical age of the world.

Now, these immense results have been gained by the application to the study of Nature of a method which was so admirably described by Lord Bacon in his "Novum Organon," and which is now generally called the experimental method. What we observe in Nature is an orderly succession of phenomena. The ancients speculated about these phenomena as well as ourselves, but they contented themselves with speculations, animating Nature with the products of their wild fancies. Their great master, Aristotle, has never been excelled in the art of dialectics; but his method of logic applied to the external world was of very necessity an utter failure. It is frequently said, in defense of the exclusive study of the records of ancient learning, that they are the products of thinking, loving, and hating men, like ourselves, and it is claimed that the study of science can never rise to the same nobility because it deals only with *lifeless* matter. But this is a mere play on words, a repetition of the error of the old schoolmen. Physical science is noble because it does deal with thought, and with the very noblest of all thought. Nature at once manifests and conceals an Infinite Presence: Her methods and orderly successions are the manifestations of Omnipotent Will; Her contrivances and laws the embodiment of Omniscient Thought. The disciples of Aristotle so signally failed simply because they could see in Nature only a reflection of their idle fancies. The followers of Bacon have so gloriously succeeded because they approached Nature as humble students, and, having first learned how to question Her, have been content to be taught and not sought to teach. The ancient logic never relieved a moment of pain, or lifted an ounce of the burden of human misery. The modern logic has made a very large share of material comfort the common heritage of all civilized men.

In what, then, does this Baconian system consist? Simply in these elements: 1. Careful observation of the conditions under which a given phenomenon occurs; 2. The varying of these conditions by experiments, and observing the effects produced by the variation. We

thus find that some of the conditions are merely accidental circumstances, having no necessary connection with the phenomenon, while others are its invariable antecedent. Having now discovered the true relations of the phenomenon we are studying, a happy guess, suggested probably by analogy, furnishes us with a clew to the real causes on which it depends. We next test our guess by further experiments. If our hypothesis is true, this or that must follow; and, if in all points the theory holds, we have discovered the law of which we are in search. If, however, these necessary inferences are not realized, then we must abandon our hypothesis, make another guess, and test that in its turn. Let me illustrate by two well-known examples:

The, of old, universally accepted principle that all living organisms are propagated by seeds or germs (*omnia ex ovo*) has been seriously questioned by a modern school of naturalists. Various observers have maintained that there were conditions under which the lower forms of organic life were developed independently of all such accessories, but other, and equally competent, naturalists who have attempted to investigate the subject, have obtained conflicting results. Thus it was observed that certain low forms of life were quite constantly developed in beef-juice that had been carefully prepared and hermetically sealed in glass flasks, even after these flasks had been exposed for a long time to the temperature of boiling water. "Here," proclaims the new school, "is unmistakable evidence of spontaneous generation; for, if past experience is any guide, all germs must have been killed by the boiling water." "No," answer the more cautious naturalists, "you have not yet proved your point. You have no right to assume that all germs are killed at this temperature." The experiments, therefore, were repeated under various conditions and at different temperatures, but with unsatisfactory results, until Pasteur, a distinguished French physicist, devised a very simple mode of testing the question. He reasoned thus: "If, as is generally believed, the presence of invisible spores in the air is an essential condition of the development of these lower growths, then their production must bear some proportion to the abundance of these spores. Near the habitations of animals and plants, where the spores are known to be in abundance, the development would be naturally at a maximum, and we should expect that the growth would diminish in proportion as the microscope indicated that the spores diminished in the atmosphere." Accordingly, Pasteur selected a region in the Jura Mountains suitable for his purpose, and repeated the well-known experiment with beef-juice, first at the inn of a town at the foot of the mountains, and then at various elevations up to the bare rocks which covered the top of the ridge, a height of some 8,000 feet. At each point he sealed up beef-juice in a large number of flasks and watched the result. He found that while in the town the animalcules were developed in almost all the flasks, they appeared

only in two or three out of a hundred cases where the flasks had been sealed at the top of the mountain, and to a proportionate extent in those sealed at the intermediate elevations. What, now, did these experiments prove? Simply this, that the development of these organic forms was in direct proportion to the number of germs in the air. It did not settle the question of spontaneous generation, but it showed that false conclusions had been deduced from the experiments which had been cited to prove it.

A still more striking illustration of the same method of questioning Nature is to be found in the investigation of Sir Humphry Davy on the composition of water. The voltaic battery which works our telegraphs was invented by Volta in 1800; and later, during the same year, it was discovered in London, by Nicholson and Carlisle, that this remarkable instrument had the power of decomposing water. These physicists at once recognized that the chief products of the action of the battery on water were hydrogen and oxygen gases, thus confirming the results of Cavendish, who in 1781 had obtained water by combining these elementary substances; oxygen having been previously discovered in 1775, and hydrogen at least as early as 1766. It was, however, very soon also observed that there were always formed by the action of the battery on water, besides these aëriform products, an alkali and an acid, the alkali collecting around the negative pole and the acid around the positive pole of the electrical combination. In regard to the nature of this acid and alkali there was the greatest difference of opinion among the early experimenters on this subject. Cruickshanks supposed that the acid was nitrous acid, and the alkali ammonia. Desormes, a French chemist, attempted to prove that the acid was muriatic acid; while Brugnatelli asserted that a new and peculiar acid was formed, which he called the electric acid.

It was in this state of the question that Sir Humphry Davy began his investigation. From the analogies of chemical science, as well as from the previous experiments of Cavendish and Lavoisier, he was persuaded that water consisted solely of oxygen and hydrogen gases, and that the acid and alkali were merely adventitious products. This opinion was undoubtedly well-founded; but, great disciple of Bacon as he was, Davy felt that his opinion was worth nothing unless substantiated by experimental evidence, and accordingly he set himself to work to obtain the required proof.

In Davy's first experiments the two glass tubes which he used to contain the water were connected together by an animal membrane, and he found, on immersing the poles of his battery in their respective tubes, that, besides the now well-known gases, there were really formed muriatic acid in one tube and a fixed alkali in the other. Davy at once, however, suspected that the acid and alkali came from common salt contained in the animal membrane, and he therefore rejected this material and connected the glass tubes by carefully-washed cotton

fibre: when, on submitting the water as before to the action of the voltaic current, and continuing the experiment through a great length of time, no *muriatic* acid appeared; but he still found that the water in the one tube was strongly alkaline, and in the other strongly acid, although the acid was, chiefly at least, nitrous acid. A part of the acid evidently came from the animal membrane, but not the whole, and the source of the alkali was as obscure as before. Davy then made another guess. He knew that alkali was used in the manufacture of glass; and it occurred to him that the glass of the tubes, decomposed by the electric current, might be the origin of the alkali in his experiments. He therefore substituted for the glass tubes cups of agate, which contains no alkali, and repeated the experiment, but still the troublesome acid and alkali appeared. Nevertheless, he said, it is possible that these products may be derived from some impurities existing in the agate cups, or adhering to them; and so, in order to make his experiments as refined as possible, he rejected the agate vessels and procured two conical cups of pure gold, but on repeating the experiments the acid and alkali again appeared.

And now let me ask who is there of us who would not have concluded at this stage of the inquiry that the acid and alkali were essential products of the decomposition of water? But not so with Davy. He knew perfectly well that all the circumstances of his experiments had not been tested, and until this had been done he had no right to draw such a conclusion. He next turned to the water he was using. It was distilled water, which he supposed to be pure, but still, he said, it is possible that the impurities of the spring-water may be carried over to a slight extent by the steam in the process of distillation, and may therefore exist in my distilled water to a sufficient amount to have caused the difficulty. Accordingly he evaporated a quart of this water in a silver dish, and obtained seven-tenths of a grain of dry residue. He then added this residue to the small amount of water in the gold cones and again repeated the experiment. The proportion of alkali and acid was sensibly increased.

You think he has found at last the source of the acid and alkali in the impurities of the water. So thought Davy, but he was too faithful a disciple of Bacon to leave this legitimate inference unverified. Accordingly he repeatedly distilled the water from a silver alembic until it left absolutely no residue on evaporation, and then with water, which he knew to be pure, and contained in vessels of gold from which he knew it could acquire no taint, he still again repeated the already well-tried experiment. He dipped his test-paper into the vessel connected with the positive pole, and the water was still decidedly acid. He dipped the paper into the vessel connected with the negative pole, and the water was still alkaline.

You might well think that Davy would have been discouraged here. But not in the least. The path to the great truths which

Nature hides often leads through a far denser and a more bewildering forest than this; but then there is not infrequently a *blaze* on the trees which points out the way, although it may require a sharp eye in a clear head to see the marks. And Davy was well enough trained to observe a circumstance which showed that he was now on the right path and heading straight for the goal. On examining the alkali formed in this last experiment, he found that it was not, as before, a fixed alkali, soda or potash, but the volatile alkali ammonia. Evidently the fixed alkali came from the impurities of the water, and when, on repeating the experiment with pure water in agate cups or glass tubes, the same results followed, he felt assured that so much at least had been established. There was still, however, the production of the volatile alkali and of nitrous acid to be accounted for. As these contain only the elements of air and water, Davy thought that possibly they might be formed by the combination of hydrogen at the one pole and of oxygen at the other with the nitrogen of the air, which was necessarily dissolved in the water. In order, therefore, to eliminate the effect of the air, he again repeated the experiment under the receiver of an air-pump from which the atmosphere had been exhausted, but still the acid and alkali appeared in the two cups.

Davy, however, was not discouraged by this, for the *blazes* on the trees were becoming more numerous, and he now felt sure that he was fast approaching the end. He observed that the quantity of acid and alkali had been greatly diminished by exhausting the air, and this was all that could be expected, for, as Davy knew perfectly well, the best air-pumps do not remove all the air. He therefore for the last experiment not only exhausted the air, but replaced it with pure hydrogen, and then exhausted the hydrogen and refilled the receiver with the same gas several times in succession, until he was perfectly sure that the last traces of air had been as it were washed out. In this atmosphere of pure hydrogen he allowed the battery to act on the water, and not until the end of twenty-four hours did he disconnect the apparatus. He then dips his test-paper into the water connected with the positive pole, and there is no trace of acid; he dips it into the water at the negative pole, and there is no alkali; and you may judge with what satisfaction he withdraws those slips of test-paper, whose unaltered surfaces showed that he had been guided at last to the truth, and that his perseverance had been rewarded.

The fame of Sir Humphry Davy rests on his discovery of the metals of the alkalies and earths which first revealed the wonderful truth that the crust of our globe consists of metallic cinders; but none of these brilliant results show so great scientific merit or such eminent power of investigating Nature as the experiments which I have just detailed. I have not, however, described them here for the purpose of glorifying that renowned man. His honored memory needs no such office at my hands. My only object was to show you what is

meant by the Baconian method of science, and to give some idea of the nature of that modern logic which within the last fifty years has produced more wonderful transformations in human society than the author of Aladdin ever imagined in his wildest dreams. In this short address I can of course give you but a very dim and imperfect idea of what I have called the Baconian system of experimental reasoning. Indeed, you cannot form any clear conception of it, until in some humble way you have attempted to use the method, each one for himself, and you have come here in order that you may acquire such experience. My object, however, will be gained if these illustrations serve to give emphasis to the following statements, which I feel I ought to make at the opening of these courses of instruction—statements which have an especial appropriateness in this place; since I am addressing teachers, who are in a position to exert an important influence on the system of education in this country.

In the first place, then, I must declare my conviction that no educated man can expect to realize his best possibilities of usefulness without a practical knowledge of the methods of experimental science. If he is to be a physician, his whole success will depend on the skill with which he can use these great tools of modern civilization. If he is to be a lawyer, his advancement will in no small measure be determined by the acuteness with which he can criticise the manner in which the same tools have been used by his own or his opponent's clients. If he is to be a clergyman, he must take sides in the great conflict between theology and science, which is now raging in the world, and, unless he wishes to play the part of the doughty knight Don Quixote, and think he is winning great victories by knocking down the imaginary adversaries which his ignorance has set up, he must try the steel of his adversary's blade. Let me be fully understood. It is not to be expected or desired that many of our students should become professional men of science. The places of employment for scientific men are but few, and more in the future than in the past they will naturally be secured by those whom Nature has endowed with special aptitudes or tastes—usually the signs of aptitudes—to investigate her laws. That our country will always offer an honorable career to her men of genius, we have every reason to expect, and these born students of Nature will usually follow the plain indications of Providence without encouragement or direction from us. It is different, however, with the great body of earnest students who are conscious of no special aptitudes, but who are desirous of doing the best thing to fit themselves for usefulness in the world; and I feel that any system of education is radically defective which does not comprise a sufficient training in the methods of experimental science to make the mass of our educated men familiar with this tool of modern civilization: so that when, hereafter, new conquests over matter are announced, and great discoveries are proclaimed, they may be able not

only to understand but also to criticise the methods by which the assumed results have been reached, and thus be in a position to distinguish between the true and the false. Whether we will or not, we must live under the direction of this great power of modern society, and the only question is whether we will be its ignorant slave or its intelligent servant.

In the second place, it seems fitting that I should state to you what I regard as the true aims to be kept in view in a course of scientific study, and to give my reasons for the methods we have adopted in arranging the courses you are about beginning.

In our day there has arisen a warm discussion as to the relative claims of two kinds of culture, and attempts are made to create an antagonism between them. But all culture is the same in spirit. Its object is to awaken and strengthen the powers of the mind; for these, like the muscles of the body, are developed and rendered strong and active only by exercise; while on the other hand they may become atrophied from mere want of use. Science culture differs in its methods from the old classical culture, but it has the same spirit and the same object. You must not, therefore, expect me to advocate the former at the expense of the latter; for, although I have labored assiduously during a quarter of a century to establish the methods of science teaching which have now become general, I am far from believing that they are the only true modes of obtaining a liberal education. So far from this, if it were necessary to choose one of two systems, I should favor the classical; and why?

Language is the medium of thought, and cannot be separated from it. He who would think well must have a good command of language, and he who has the best command of language I am almost tempted to say will think the best. For this reason a certain amount of critical study of language is essential for every educated man, and such study is not likely to be gained except through the great ancient languages; the advocates of classical scholarship frequently say, cannot be gained. I am not ready to accept this dictum; but I most willingly concede that in the present state of our schools it is not likely to be gained. I never had any taste myself for classical studies; but I know that I owe to the study a great part of the mental culture which has enabled me to do the work that has fallen to my share in life. But while I concede all this, I do not believe, on the other hand, that the classical is the only effective method of culture; you evidently do not think so, for you would not be here if you did. But, in abandoning the old tried method, which is known to be good, for the new, you must be careful that you gain the advantages which the new offers; and you will not gain the new culture you seek unless you study science in the right way. In the classical departments the methods are so well established, and have been so long tested by experience, that there can hardly be a wrong way. But in science there is not only a wrong

way, but this wrong way is so easy and alluring, that you will most certainly stray into it unless you strive earnestly to keep out of it. Hence I am most anxious to point out to you the right way, and do what I can to keep you in it; and you will find that our courses and methods have been devised with this object.

When advocating in our mother University of Cambridge, in Old England, the claims of scientific culture, I was pushed with an argument which had very great weight with the eminent English scholars present, and which you will be surprised to learn was regarded as fatal to the success of the science *triposes* then under debate. The argument was, that the experimental sciences could not be made the subjects of competitive examinations. Some may smile at such an objection; but, as viewed from the English stand-point, there was really a great deal in it, and the argument brought out the radical difference between scientific and classical culture. The old method of culture may be said to have culminated in the competitive examinations of the English universities. We have no such examinations here. Success depends not simply on knowing your subject thoroughly, but on having it at your fingers' ends, and those fingers so agile that they can accomplish not only a prodigious amount of work in a short time, but can do this work with absolute accuracy. For the only approach we make to an experience of this kind, we must look to our athletic contests. It may of course be doubted whether the ability, once in a man's life, to perform such mental feats, is worth what it costs. Still it implies a very high degree of mental culture, and it is perfectly certain that the experimental sciences give no field for that sort of mental prize-fights. It is easy to prepare written examinations which will show whether the students have been faithful to their work, but they cannot be adapted to such competitions as I have described without abandoning the true object of science culture. The ability of the scientific student can only be shown by long-continued work at the laboratory-table, and by his success in investigating the problems which Nature presents.

We have here struck the true key-note of the scientific method. The great object of all our study should be to study Nature, and all our methods should be directed to this one object. This aim alone will ennoble our scholarship as students, and will give dignity to our scientific calling as men of science. It is this high aim, moreover, which vindicates the worth of the mode of culture we have chosen. What is it that ennobles literary culture but the great minds which, through this culture, have honored the nations to which they belong? The culture we have chosen is capable of even greater things; not because science is nobler than art, for both are equally noble;—it is the thought, the conception, which ennobles, and I care not whether it be attained through one kind of exercise of the mental faculties or another;—but we are capable of grander and nobler thoughts than Plato,

Cicero, Shakespeare, or Newton, because we live in a later period of the world's history; when, through science, the world has become richer in great ideas. It is, I repeat, the great thought which ennobles, and it ennobles because it raises to a higher plane that which is immortal in our manhood.

If I have made my meaning clear, and if you sympathize with my feelings, you will understand why I regard culture as so important to the individual and to the nation. The works of Shakespeare and of Bacon are of more value to England to-day than the memories of Blenheim or Trafalgar; and those great minds will still be living powers in the world when Marlborough and Nelson are only remembered as historical names. I therefore believe that it is the first duty of a country to foster the highest culture, and that it should be the aim of every scholar to promote this culture both by his own efforts and his active influence. A nation can become really great in no other way. We live in a country of great possibilities; and the danger is that, as with many men I have known in college, of great potential abilities, the greatness will end where it begins. The scholars of the country should have but one voice in this matter, and urge upon the government and upon individuals the duty of encouraging and supporting mental culture for its own sake. The time has passed when we can afford to limit the work of our higher institutions of learning to teaching knowledge already acquired. Henceforth the investigation of unsolved problems, and the discovery of new truth, should be one of the main objects at our American universities, and no cost grudged, which is required to maintain at them the most active minds, in every branch of knowledge which the country can be stimulated to produce. I could urge this on the self-interest of the nation as an obvious dictate of political economy. I could say, and say truly, that the culture of science will help us to develop those latent resources of which we are so proud; will enable us to grow two blades of grass where one grew before; to extract a larger per cent. of metal from our ores; to economize our coal, and in general to direct our waiting energies so that they may produce a more abundant pecuniary reward. I could tell of Galvani studying for twenty long years to no apparent purpose the twitching of frogs' hind-legs and thus sowing the seed from which has sprung the greatest invention of modern times. Or, if our Yankee impatience would be unwilling to wait half a century for the fruit to ripen, I could point to the purely theoretical investigations of organic chemistry, which in less than five years have revolutionized one of the great industries of Europe, and liberated thousands of acres for a more beneficent agriculture. This is all true, and may be urged properly if higher considerations will not prevail. It is an argument I have used in other places, but I will not use it here; although I gladly acknowledge the Providence which brings at last even material fruits to re-

ward conscientious labor for the advancement of knowledge and the intellectual elevation of mankind. I would rather point to that far greater multitude who worked in faith for the love of knowledge, and who ennobled themselves and ennobled their nation, not because they added to its material prosperity, but because they made themselves and made their fellows more noble men.

I come back now again to the moral of all this, to urge upon you, as the noblest patriotism and the most enlightened self-interest, the duty of striving for yourselves and encouraging in others the highest culture in the studies you have chosen, and this culture with one end in view to advance knowledge. I am far, of course, from advising you to grapple immaturely with unsolved problems, or, when you have gained the knowledge with which you can dare to venture from the beaten track, to undertake work beyond your power. Many a young scientific man has suffered the fate of Icarus in attempting to soar too high. Moreover, I am far from expecting that all or many of you will ever have the opportunity of going beyond the well-explored fields of knowledge; but you can all have the aim, and that aim will make your work more worthy and more profitable to yourselves. Every American boy cannot be President of the United States, but if, as our English cousins allege, he believes that he can be, the very belief makes him an abler man.

We have dwelt long enough on these generalities, and it is time to come down to commonplaces, and to inquire what are the essential conditions of this scientific culture which shall fit us to investigate Nature; and the first thought that occurs to me in this connection may be expressed thus: Science presents to us two aspects, which I may call its objective and its subjective aspect. Objectively it is a body of facts, which we have to observe, and subjectively it is a body of truths, conclusions, or inferences, deduced from these facts; and the two sides of the subject should always be kept in view. I propose next to say a few words in regard to each of these two aspects of our study, and in regard to the best means of training our faculties so as to work successfully in each sphere. First, then, success in the observation of phenomena implies three qualities at least, namely, quickness and sharpness of perception, accuracy in details, and truthfulness; and on its power to cultivate these qualities a large part of the value of science, as a means of education, depends. To begin with the cultivation of our perceptions. We are all gifted with senses, but how few of us use them to the best advantage! "We have eyes and see not;" for, although the light paints the picture on the retina, our dull perceptions give no attention to the details, and we retain only a confused impression of what has passed before our eyes. "But how," you may ask, "are we to cultivate this sharpness of perception?" I answer, only by making a conscious effort to fix our attention on the objects we study, until the habit becomes a second nature. I have often noticed,

with surprise, the power which uneducated miners frequently possess, of recognizing many minerals at sight. This they have acquired by long experience and close familiarity with such objects, and such power of observation is with them so purely a habit that they are frequently unable to state clearly the grounds on which their conclusions are based. They recognize the minerals by what in common language is called their *looks*, and they notice delicate differences in the *looks* to which most men are blind. It is, however, the business of the scientific mineralogist to analyze these *looks*, and to point out in what the differences consist; so that by fixing his attention on these points the student may gain, by a few hours' study, the power which the miner acquires only after long experience. The chief difficulty, however, which we find in teaching mineralogy is, that the students do not readily see the differences when they are pointed out, or, if they see them, do not remember them with sufficient precision to render their subsequent observations conclusive and precise. This either arises from a failure to cultivate the powers of observation in childhood, or the subsequent blunting of them by disuse. The ladies will scout the idea that a brooch of cut-glass is as ornamental as one of diamond, and yet I venture to assert that there is not one person in fifty, at least of those who have not made a study of the subject, who can tell the difference between the two. The external appearance depends simply on what we call lustre. The lustre of glass is vitreous, that of the diamond adamantine, and I know of no other distinction which it is more difficult for students to recognize than this. Those of you who study mineralogy will experience this difficulty, and it can be overcome only by giving careful attention to the subject. The teacher can do nothing more than put in your hands the specimens which illustrate the point, and you must study these specimens until you see the difference. It is a question of sight, not of understanding, and all the optical theories of the cause of the lustre will not help you in the least toward seeing the difference between diamond and glass, or anglesite and heavy spar. Another illustration of the same fact is the constant failure of students to distinguish by the eye alone between the two minerals called copper-glance and gray copper. There is a difference of color and lustre which, although usually well marked, it requires an educated eye to distinguish.

Mineralogy undoubtedly demands a more careful cultivation of the perceptions than the other branches of chemistry; but still you will find abundant practice for close observation in them all. I have often known students to reach erroneous results in qualitative analysis by mistaking a white precipitate in a colored liquid for a colored precipitate; or by not attending to similar broad distinctions which would have been obvious to any careful observer; and so in quantitative analysis, mere delicacy of touch or handling is a great element of success.

But I must pass on to speak of the importance in the study of Nature of accuracy in detail, which is the second condition of successful observation of which I spoke. We must cultivate not only accuracy in observing details, but also accuracy in following details which have been laid down by others for our guidance. In science we cannot draw correct conclusions from our premises unless we are sure that we have all the facts, and what seemed at first an unimportant detail often proves to be the determining condition of the result; and, again, if we are told that under certain conditions a certain sign is the proof of the presence of a certain substance, we have no right to assume that the sign is of any value unless the conditions are fulfilled. A black precipitate, for example, obtained under certain conditions, is a proof of the presence of nickel, but we cannot assert that we have found nickel unless we have followed out those details in every particular. Of course, we must avoid empiricism as far as we can. We must seek to learn the reasons of the details, and such knowledge will not only render our works intelligent, but will also frequently enable us to judge how far the details are essential, and to what extent our processes may be varied with safety. We must also avoid trifling, and above all "the straining at a gnat and swallowing a camel," as is the habit with triflers. Large knowledge and good judgment will avoid all such errors; but, if we must choose between fussiness and carelessness, the first is the least evil. Slovenly work means slovenly results, and habits of carefulness, neatness, and order, produce as excellent fruits in the laboratory as in the home.

Last in order but first in importance of the conditions of successful observation, mentioned above, stands truthfulness. Here you may think I am approaching a delicate subject, of which even to speak might seem to cast a reproach. But not so at all. I am not speaking here of conscious deception, for I assume that no one who aspires to be a student of Nature can be guilty of that. But I am speaking of a quality whose absence is not necessarily a mark of sinfulness, but whose possession, in a high degree, is a characteristic of the greatest scientific talent. As every lawyer knows, he is a rare man whose testimony is not colored by his interests, and a very large amount of self-deception is compatible with conscious honesty of purpose. So among scientific students the power to keep the mind unbiased and not to color our observations in the least degree, is one of the rarest as it is one of the noblest of qualities. It is a quality we must strive after with all our might, and we shall not attain it unless we strive. Remember, our observations are our data, and, unless accurate, every thing deduced from them must have the taint of our deception. We cannot deceive Nature, however much we may deceive ourselves; and there is many a student who would cut off his right hand rather than be guilty of a conscious untruth, who is yet constantly untruthful to himself. Every year students of mineralogy present to me written descriptions of

mineral specimens which particularize, as observed, characters that do not appear on the specimens given them to determine, although they may be the correct characters of some other mineral. There is usually no want of honesty in this, but, deceived by some accident, the student has made a wrong guess, and then imagined that he saw on the specimen those characters which he knew from the descriptions ought to appear on the assumed mineral. So, also, it not unfrequently happens that a student in qualitative analysis, who has obtained some hints in regard to the composition of his solution, will torture his observations until they seem to him to confirm his erroneous inferences; and again the student in quantitative analysis, who finds out the exact weight he ought to obtain, is often insensibly influenced by this knowledge—in the washing and ignition of his precipitate, or in some other way—and thus obtains results whose only apparent fault may be a too close agreement with theory, but which, nevertheless, are not accurate because not true. It is evident how fatal such faults as these must be to the investigation of truth, and they are equally destructive of all scientific scholarship. Their effect on the student is so marked that although he may deceive himself, he will rarely deceive his teacher. That he should lose confidence in his own results is, to the teacher, one of the most marked indications of such false methods of study, but the student usually refers his want of success to any cause but the real one—his own untruthfulness. He will complain of the teacher, or of the methods of instruction, and may even persuade himself that all scientific results are as uncertain as his own. As I have said, mere ordinary truthfulness, which spurns any conscious deception, will not save us from falling into such faults. Our scientific study demands a much higher order of truthfulness than this. We should so love the truth above all price as to strive for it with single-hearted and unswerving purpose. We must be constantly on our guard to avoid any circumstance which would tend to bias our minds or warp our judgments, and we must make the attainment of the truth our sole motive guide and end.

It remains for me, before closing this address, to say a few words on what I have called the subjective aspect of scientific study. Science offers us not only a mass of phenomena to be observed, but also a body of truths which have been deduced from these observations; and, without the power of drawing correct inferences from the data acquired, exact observations would be of little value. I have already described the inductive method of reasoning, and illustrated it by two noteworthy examples, and, in a humbler measure, we must apply the same method in our daily work in the laboratory. We must learn how to vary our experiments so as to eliminate the accidental circumstances, and make evident the essential conditions of the phenomena we are studying. Such power can only be acquired by practice, and a somewhat long experience in active teaching has convinced me that

there is no better means of training this logical faculty than the study of qualitative chemical analysis in which many of you are to engage. The results of the processes of qualitative analysis are perfectly definite and trustworthy; but they are only reached by following out the indications of experiments which are frequently obscure, and even apparently contradictory; reconciling by new experiments the seeming discrepancies, and, at last, having eliminated all other possible causes of the phenomena observed, discovering the true nature of the substances under examination. The study of mineralogy affords an almost equally good practice, although in a somewhat different form. By comparing carefully many specimens of the same mineral, you learn to distinguish the accidental from the essential characters, and on this distinction you must base your inferences in regard to the nature of the specimens you may be called upon to determine. A single remark occurs to me which may aid you in cultivating this scientific logic.

Do not attempt to reason on insufficient data. Multiply your observations or experiments, and, when your premises are ample, the conclusion will generally take care of itself. Are you in doubt in regard to a mineral specimen? Repeat your observations again and again, multiply them with the aid of the blow-pipe or goniometer, compare the specimen with known specimens which it resembles, until either your doubts are removed, or you are satisfied that you are unequal to the task; and remember that, in many cases, the last is the only honest conclusion. Are you in doubt in regard to the reactions of the substance you are analyzing, whether they are really those of a metal you suspect to be present? Do not rest in such a frame of mind, and, above all, do not try to remove the doubt by comparing your experience with that of your neighbor: but multiply your own experiments; procure some compound of the metal, and compare its reactions with those you have observed, until you reach either a positive or a negative result. Remember that the way to remove your doubts is to widen your own knowledge, and not to depend on the knowledge of others. When your knowledge of the facts is ample, your inferences will be satisfactory, and then an unexplained phenomenon is the guide to a new discovery. Do not be discouraged if you have to labor long in the dark before the day begins to dawn. It will at last dawn to you, as it has dawned to others before, and, when the morning breaks, you will be satisfied with the result of your labor.

Moreover, I feel confident that such experience will very greatly tend to increase your appreciation of the value of scientific studies in training the reasoning faculties of the mind. This, as every one must admit, is the best test of their utility in a scheme of education, and it is precisely here that I claim for them the very highest place. It has generally been admitted that mathematical studies are peculiarly well adapted to train the logical faculties, but still many persons have main-

tained that, since the mathematics deal wholly with absolute certainties, an exclusive devotion to this class of subjects unfits the mind for weighing the probable evidence by which men are chiefly guided in the affairs of life. But, without attempting to discuss this question, on which much might be said on both sides, it is certain that no such objection can be urged against the study of the physical sciences if conducted in the manner I have attempted to describe. These subjects present to the consideration of the student every degree of probable evidence, accustoming him to weigh all the evidence for or against a given conclusion, and to reject or to provisionally accept only on the balance of probabilities. Moreover, in practical science, the student is taught to follow out a chain of probable evidence with care and caution, to eliminate all accidental phenomena, and supply, by experiment or observation, the missing links, until he reaches the final conclusion—an intellectual process which, though based wholly on probable evidence, may have all the force and certainty of a mathematical demonstration. Indeed, that highly-valued scientific acumen and skill which enables the student to brush away the accidental circumstances by which the laws of Nature are always concealed until the truth stands out in bold relief, is but a higher phase of the same talent which marks professional skill in all the higher walks of life. The physician who looks through the external symptoms of his patient to the real disease which lurks beneath; the lawyer, who disentangles a mass of conflicting testimony, and follows out the truth successfully to the end; the statesman, who sees beneath the froth of political life the great fundamental principles which will inevitably rule the conduct of the State, and thus foresees and provides for the coming change; the general, who discovers amid the confusion of the battle-field the weak point of his enemy's front; the merchant, even, who can interpret the signs of the unsettled market—employ the same faculty, and frequently in not a much lower degree, that discovered the law of gravitation, and which, since the days of Newton, has worked so successfully to unveil the mysteries of the material creation.

Moreover, I hope, my friends, that you will come to value scientific studies, not simply because they cultivate the perceptive and reasoning faculties, but also because they fill the mind with lofty ideals, elevated conceptions, and noble thoughts. Indeed, I claim that there is no better school in which to train the æsthetical faculties of the mind, the tastes, and the imagination, than the study of natural science. The beauty of Nature is infinite, and the more we study her works the more her loveliness unfolds. The upheaved mountain, with its mantle of eternal snow; the majestic cataract, with its whirl and roar of waters; the sunset cloud, with its blending of gorgeous hues, lose nothing of their beauty for him who knows the mystery they conceal. On the contrary, they become, one and all, irradiated by the Infinite Presence which shines through them, and fill the mind with grander

conceptions and nobler ideas than your uneducated child of Nature could ever attain. Remember that I am not recommending an exclusive devotion to the natural sciences. I am only claiming for them their proper place in the scheme of education, and I do not, of course, deny the unquestionable value of both the ancient and the modern classics in cultivating a pure and elevated taste. But I do say that the poet-laureate of England has drawn a deeper inspiration from Nature interpreted by science than any of his predecessors of the classical school; and I do also affirm that the pre-Raphaelite school of painting, with all its grotesque mimicry of Nature, embodies a truer and purer ideal than that of any Roman fable or Grecian dream. And what shall we say of the imagination? Where can you find a wider field for its exercise than that opened by the discoveries of modern science? And as the mind wanders over the vast expanse, crossing boundless spaces, dwelling in illimitable time, witnessing the displays of immeasurable power, and studying the adaptations of Omniscient skill, it lives in a realm of beauty, of wonder, and of awe, such as no artist has ever attained to in word, in sound, in color, or in form. And if such a life does not lead man to feel his own dependence, to yearn toward the Infinite Father, and to rest on the bosom of Infinite Love, it is simply because it is not the noble in intellect, not the great in talent, not the profound in knowledge, not the rich in experience, not the lofty in aspiration, not the gifted in imagery, but solely the pure in heart, who see God.

Such, then, is a very imperfect presentation of what I believe to be the value of scientific studies as a means of education. In what I have stated I have implied that, for these studies to be of any real value, the end must be constantly kept in view, and every thing made subservient to the one great object. To study the natural sciences merely as a collection of interesting facts which it is well for every educated man to know, seldom serves a useful purpose. The young mind becomes wearied with the details, and soon forgets what it has never more than half acquired. The lessons become an exercise of the memory and of nothing more; and if, as is too frequently the case, an attempt is made to cram the half-formed mind in a single school-year with an epitome of half the natural sciences—natural philosophy, astronomy, and chemistry, physiology, zoölogy, botany, and mineralogy, following each other in rapid succession—these studies become a great evil, an actual nuisance, which I should be the first to vote to abate. The tone of mind is not only not improved, but seriously impaired, and the best product is a superficial, smattering smartness, which is the crying evil not only of our schools, but also of our country. In order that the sciences should be of value in our educational system, they must be taught more from things than from books, and *never* from books without the things. They must be taught, also, by real living teachers, who are themselves interested in what they teach, are inter-

ested also in their pupils, and understand how to direct them aright. Above all, the teachers must see to it that their pupils study with the understanding and not solely with the memory, not permitting a single lesson to be recited which is not thoroughly understood, taking the greatest care not to load the memory with any useless lumber, and eschewing *merely* memorized rules as they would deadly poison. The great difficulty against which the teachers of natural science have to contend in the colleges are the wretched tread-mill habits the students bring with them from the schools. Allow our students to memorize their lessons, and they will appear respectably well, but you might as easily remove a mountain as to make many of them think. They will solve an involved equation of algebra readily enough so long as they can do it by turning their mental crank, when they will break down on the simplest practical problem of arithmetic which requires of them only thought enough to decide whether they shall multiply or divide. Many a boy of good capabilities has been irretrievably ruined, as a scholar, by being compelled to learn the Latin grammar by rote at an age when he was incapable of understanding it; and I fear that schools may still be found where young minds are tortured by this stupefying exercise. Those of us who have faith in the educational value of scientific studies are most anxious that the students who resort to our colleges should be as well fitted in the physical sciences as in the classics, for otherwise the best results of scientific culture cannot be expected. As it is, our students come to the university, not only with no preparation in physical science, but with their perceptive and reasoning faculties so undeveloped that the acquisition of the elementary principles of science is burdensome and distasteful: and good scholars, who are ambitious of distinction, can more readily win their laurels on the old familiar track than on an untried course of which they know nothing, and for which they must begin their training anew. We have improved our system of instruction in the college as fast as we could obtain the means, but we are persuaded that the best results cannot be reached without the coöperation of the schools. We feel, therefore, that it is incumbent upon us, in the first place, to do every thing in our power to prove to the teachers of this country how great is the educational value of the physical sciences, when properly taught; and, secondly, to aid them in acquiring the best methods of teaching these subjects. It is with such aims that our summer courses have been instituted, and your presence here in such numbers is the best evidence that they have met a real want of the community. We welcome you to the university and to such advantages as it can afford, and we shall do all in our power to render your brief residence here fruitful both in experience and in knowledge; hoping also that the university may become to you, as she has to so many others, a bright light shining calmly over the troubled sea of active life, ever suggesting lofty thoughts, encouraging

noble endeavors, and inciting all her children to work together toward those great ends, the advancement of knowledge and the education of mankind.

PHYSICAL FEATURES OF THE COLORADO VALLEY.[1]

By Major J. W. POWELL.

II.—*Cliffs and Cañons.*

SOUTH of the Uinta Mountains, and beyond the hog-backs on either side of the river, is a district known to the Indians as *Wa-ka-ri'-chits*, or the Yellow Hills. This country is elaborately embossed with low, rounded, naked hills. The rocks from which they are carved are yellow clays and shales. Some few of the shales are slate-colored, others pink; none so glaring and brilliant as the Bad-Lands of Black's Fork, but the tints are soft and delicate. The whole country is carved by a net-work of water-ways, which descend rapidly toward Green River, and the intervening hills are entirely destitute of vegetation. Looking at it from an eminence, and in the light of the mid-day sun, it appears like a billowy sea of molten gold.

To the south of these Yellow Hills, and separated from them by a gently-curved but well-defined ridge of upturned sandstone, there is a broad stretch of red and buff-colored Bad-Lands. Some of the beds are highly bituminous, and a fresh fracture reveals a black surface, but usually they weather gray. Where these bituminous rocks are found, hills and *mesas* are seen, covered, more or less, with vegetation, and the Bad-Land forms disappear. Still farther to the south, across White River, we find a continuation of these beds, but here more shaly, and interstratified with harder beds, and the alcove structure appears, somewhat like that in the Alcove Land near Green River Station. These White River alcove lands were, by General Hughes, named "Goblin City."

The Terrace Cañons and Cliffs.—A few miles south of the mouth of the Uinta, Green River enters the Cañon of Desolation. The walls of this gorge steadily increase in altitude to its foot, where it terminates abruptly at the Brown Cliffs; then the river immediately enters Gray Cañon, with low walls, steadily increasing in altitude until the foot is reached, where it terminates abruptly at the Book Cliffs. In like manner the walls of Labyrinth Cañon are low above, and increase in altitude as we descend the river, until the cañon terminates, as those above, in a line of cliffs. To these last we have given the name Orange Cliffs. We sometimes call these the Terrace Cañons. They are cut through three great inclined plateaus.

[1] From "Report on United States Geological and Geographical Survey of the Territories, Second Division." Major J. W. Powell in charge.

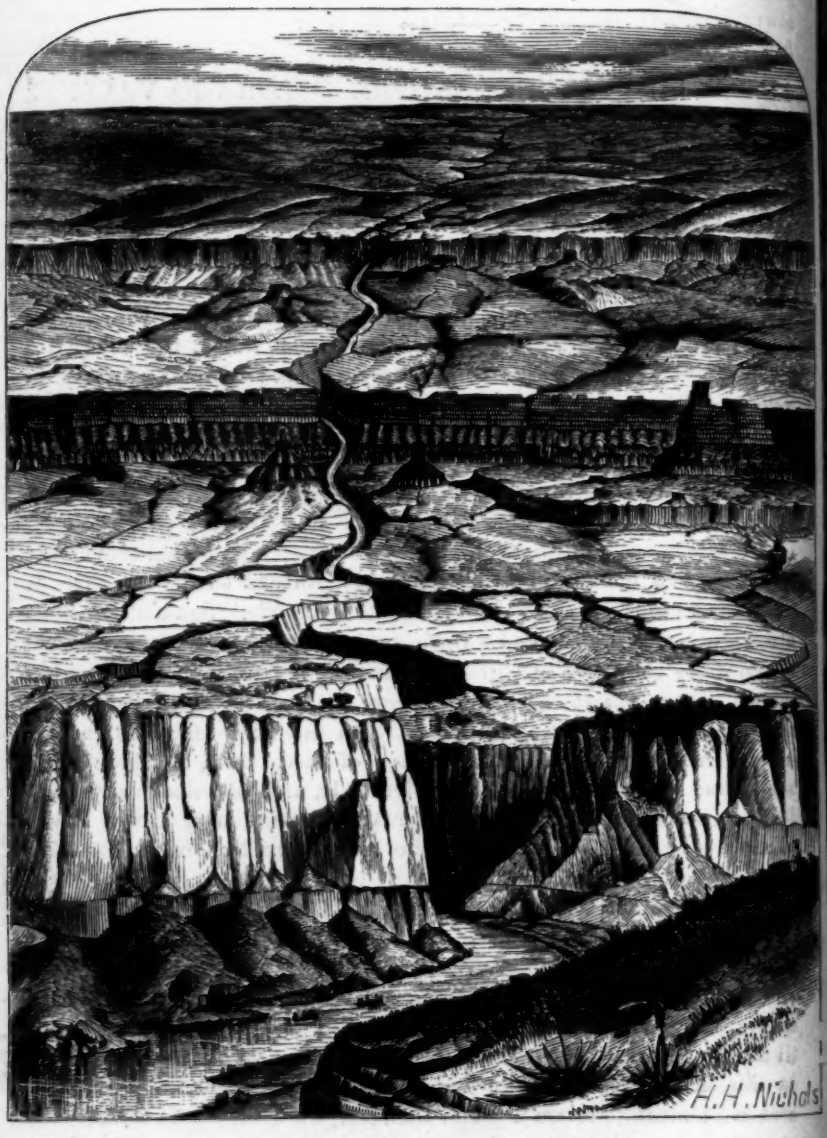


FIG. 1.—BIRD'S-EYE VIEW OF THE TERRACE CAÑON.

Conceive of three geographic terraces, many hundred feet high, and many miles in width, forming a great stairway, from the *Toom'-pin Wu-near' Tu-weap'*, below, to the valley of the Uinta, above. The lower step of this stairway, the Orange Cliffs, is more than 1,200 feet high, and the step itself is two or three score miles in width. The second step, the Book Cliffs, is 2,000 feet high, or more, and a score of miles in width. The third, or upper step, is more than 2,000 feet high. Passing along this step, for two or three score miles, we reach the valley of the Uinta; but this valley is not 5,000 or 6,000 feet higher than the *Toom'-pin Wu-near' Tu-weap'*, for the stairway is tipped backward.

Climb the Orange Cliffs, 1,200 feet high, and go north to the foot of the Book Cliffs, and you have gradually descended, so that at the foot of the Book Cliffs you are not more than 100 feet above the foot of the Orange Cliffs. In like manner the foot of the Brown Cliffs is but 200 feet higher than the foot of the Book Cliffs, and the valley of the Uinta is not quite 300 feet higher than the foot of the Brown Cliffs.

To go by land from the valley of White River to the *Toom'-pin Wu-near' Tu-weap'*, you must gradually, almost imperceptibly, climb as you pass to the south, for a distance of forty or fifty miles, until you attain an altitude of 2,500 or 3,000 feet above the starting-point. Then you descend from the first terrace, by an abrupt step, to a lower. Still continuing to the south, you gradually climb again, until you attain an altitude of more than 1,000 feet, when you arrive at the brink of another cliff, and descend abruptly to the top of the lowest terrace. Still extending your travels in the same direction, you climb gradually for a third time, until you reach the brink of the third line of cliffs, or the edge of the escarpment of the lower terrace, and here you descend by another sudden step to the plane of the river, at the foot of Labyrinth Cañon. In coming down by the river, of course you do not ascend, but you pass these terraces along the plane of the river, the upper terrace through the Cañon of Desolation, the middle terrace through Gray Cañon, and the third through Labyrinth Cañon.

The bird's-eye view (Fig. 1) is intended to show these topographic features. The escarpment below, and in the foreground, represents the Orange Cliffs, at the foot of Labyrinth Cañon; the second escarpment, the Book Cliffs, at the foot of Gray Cañon; the third, away in the distance, the Brown Cliffs, at the foot of the Cañon of Desolation. It will be seen that the three tables incline to the north, and are abruptly terminated by cliffs on the south. For want of space the whole view is shortened.

In the three cañons there are three distinct series of beds, belonging to three distinct geological periods. In the Cañon of Desolation we have Tertiary sandstones; in Gray Cañon, Cretaceous sandstones, shales, and impure limestones; between the head of Labyrinth Cañon

and the foot of Gray Cañon, rocks of Cretaceous and Jurassic Age are found, but they are soft, and have not withstood the action of the water so as to form a cañon.

These formations differ not only in geological age, but also in structure and color. It will be interesting to notice how these structural differences affect the general contour of the country, and modify its scenic aspects.

In the description of the three cañons in the history of their exploration, the attentive reader has already noticed the great variety of geological and topographic features observed as we passed along.

Let us now take a view of the three lines of cliffs. The Brown Cliffs are apparently built of huge blocks of rock, exhibiting plainly the lines of stratification. The beds are usually massive and hard, and break with an angular fracture. The whole is very irregular, and set with crags, towers, and pinnacles. The upper beds of the Book Cliffs are somewhat like those last described, and they form a cap to extensive laminated beds of blue shales, in which we see exhibited the curious effects of rain-sculpture. The whole face of the rock is set with buttresses, and these are carved with a fretwork of raised and rounded lines, that extend up and down the face of the rock, and unite below in large ridges. The little valleys between these ridgelets are the channels of rills that roll down the rocks during the storms, and from one stand-point you may look upon millions of these little water-ways.

Labyrinth Cañon is cut through an homogeneous sandstone. The features of the cañon itself have been described, but the cliffs with which it terminates present characteristics peculiar to themselves. Below, we have rounded buttresses, and mounds and hills of sand, and piles of great, angular blocks; above, the walls are of columnar structure, and sometimes great columns, seen from a distance, appear as if they were elaborately fluted. The brink of this escarpment is a well-defined edge. But if these formations extended over the underlying beds at one time, and if they have been carried away by rains and rivers, why has not the country between been left comparatively level, or embossed with hills separated by valleys? It is easy to see that a river may cut a channel, and leave its banks steep walls of rocks; but that rains, which are evenly distributed over a district, should dig it out in great terraces, is not so easy to perceive.

The climate is exceedingly arid, and the scant vegetation furnishes no protecting covering against the beating storms. But though little rain falls, that which does is employed in erosion to an extent difficult to appreciate by one who has only studied the action of water in degrading the land in a region where grasses, shrubs, and trees, bear the brunt of the storm. A little shower falls, and the water gathers rapidly into streams, and plunges headlong down the steep slopes, bearing with it loads of sand, and for a few minutes, or a few hours, the

district is traversed by brooks and creeks and rivers of mud. A clear stream is never seen without going up to a moister region on some high mountain, and no permanent stream is found, unless it has its source in such a mountain. In a country well supplied with rains, so that there is an abundance of vegetation, the water slowly penetrates the loose soil, and gradually disintegrates the underlying solid rock, quite as fast as, or even faster than, it is carried away by the wash of the rains, and the indurated rock has no greater endurance than the more friable shales and sandstones; but, in a dry climate, the softer rocks are soon carried away, while the harder rocks are washed naked, and the rains make but slow progress in tearing them to pieces.

When a great fold emerges from the sea, or rises above its base level of erosion, the axis appears above the water (or base-level) first, and is immediately attacked by the rains, and its sands are borne off to form new deposits. It has before been explained that the emergence of the fold is but little faster than the degradation of its surface, but, as it comes up, the wearing away is extended still farther out on the flanks, and the same beds are attacked in the new land which have already been carried away nearer the centre of the fold. In this way the action of erosion is continued on the same bed from the upturned axis toward the down-turned axis, and it may and does often happen that any particular bed may be entirely carried away, with many underlying rocks, nearer the former line, before it is attacked near the latter. Now, as the beds are of heterogeneous structures, some hard and others soft, the harder beds withstand the action of the storms, while the softer beds are rapidly carried away.

The manner in which these beds are degraded is very different. The softer are washed from the top, but the harder are little affected by the direct action of the waters—they are torn down by another process. As the softer beds disappear, the harder are undermined, and are constantly breaking down; are crushed, more or less, by the fall, and scattered over, and mingled with the softer beds, and are carried away with them. But the progress of this undermining and digging down of the cliff is parallel with the upturned axis of the fold, so that the cliffs face such an axis.

When the fold is abrupt, so that the rocks on either side are made to incline at a great angle, ridges are formed, and this topographic structure of a country may be found even in a land of rains, though the ridges will usually be low, rounded, and more or less irregular, while in a dry climate they will be steep and regular, and will usually culminate above in a sharp edge; but where the rocks are slightly inclined, terraces will be formed, with well-defined escarpments.

It is interesting to note the manner in which the textures of these hard capping rocks affect the contours of the cliffs. When the hard rocks are separated into well-defined layers, or beds, the cliffs will be more or less terraced, as the strata vary in hardness. This is well

FIG. 2.—BIRD'S-EYE VIEW OF THE TOOM'-PIN WU-NEAR' TU-WEAP' LOOKING TO THE NORTHEAST, showing the Sierra la Sal on the Right, the Cañons through the Centre, and Lines of Cliffs on the Left.

seen in the Brown Cliffs and the upper portion of the Book Cliffs. In the last-mentioned escarpment the harder beds are underlaid by soft, bluish shales, which appear below in the beautifully-carved buttresses.

In the Orange Cliffs there are a thousand feet of homogeneous light-red sandstone, and this is underlaid by beds of darker red, chocolate, and lilac-colored rocks, very distinctly stratified. The dark-red rocks are very hard, the chocolate and lilac are very soft, so below we have terraced and buttressed walls and huge blocks scattered about, which have fallen from the upper part of the escarpment. The homogeneous sandstone above is slowly undermined—so slowly that, as the unsupported rocks yield to the force of gravity, fissures are formed parallel to the face of the cliff. Transverse vertical fissures are also formed, and thus the wall has a columnar appearance, like an escarpment of basalt, but on a giant scale; and it is these columns that tumble over at last, and break athwart into the huge blocks which are strewed over the lower terraces.

The drainage of an inclined terrace is usually from the brink of the cliff toward the foot of the terrace above, i. e., in the direction of the dip of the strata. As the channels of these intermittent streams approach the upper escarpment, they turn and run along its foot until they meet with larger and more permanent streams, which run against the dip of the rock in a direction opposite the course of the smaller channels, and these latter usually cut either quite through the folds, or at least through the harder series of rocks which form the cliffs.

In some places the waters run down the face of the escarpment, and cut narrow cañons, or gorges, back for a greater or less distance into the cliffs, until what would, otherwise, be nearly a straight wall, is cut into a very irregular line, with salients and deep reëntering angles.

These cañons which cut into the walls also have their lateral cañons and gorges, and sometimes it occurs that a lateral cañon from each of two adjacent main cañons will coalesce at their heads, and gradually cut off the salient cliff from the ever-retreating line. In this way buttes are formed. The sides of these buttresses have the same structural characteristics as the cliffs from which they have been cut. So the buttes on the plains below the Orange Cliffs are terraced and buttressed below, and fluted and columned above. Often the upper parts of these buttes are but groups of giant columns.

The three lines of cliffs, which I have thus described, have been traced to the east but a few miles back from the river. The way in which they terminate is not known; but, from a general knowledge obtained from a hasty trip made through that country, it is believed that they are cut off by a system of monoclinal folds. To the west they are known to gradually run out in plateaus and mountains, which have another orographic origin.

Climb the cliff at the end of Labyrinth Cañon, and look over the plain below, and you see vast numbers of buttes scattered about over scores of miles, and every butte so regular and beautiful that you can hardly cast aside the belief that they are works of Titanic art. It seems as if a thousand battles had been fought on the plains below, and on every field the giant heroes had built a monument, compared with which the pillar on Bunker Hill is but a mile-stone. But no human hand has placed a block in all those wonderful structures. The rain-drops of unreckoned ages have cut them all from the solid rock.

Between the foot of Gray Cañon and the head of Labyrinth Cañon we descend through many hundred feet of soft shales, sandstones, marls, and gypsiferous rocks of a texture so friable that no cañon appears along the course of the Green, but, along the southern border of the terrace above the Orange Cliffs, buttes of gypsum are seen. Sometimes the faces of these buttes are as white as the heart of the alabaster from which they are carved, while in other places they are stained and mottled red and brown.

As we come near to the Book Cliffs the buttes are seen to be composed of the same beds as those seen in the escarpment, and we see the same light-blue buttresses and terraced summits.

On the terrace above the Book Cliffs, the buttes are less numerous, but the few seen have the angular, irregular appearance of the Brown Cliffs.

The summit of the high plateau through which the Cañon of Desolation is cut, is fretted into pine-clad hills, with nestling valleys and meadow-bordered lakes, for now we are in that upper region where the clouds yield their moisture to the soil. In these meadows herds of deer carry aloft with pride their branching antlers, and sweep the country with their sharp outlook, or test the air with their delicate nostrils for the faintest evidence of an approaching Indian hunter. Huge elk, with heads bowed by the weight of ragged horns, feed among the pines, or trot with headlong speed through the undergrowth, frightened at the report of the red-man's rifle. Eagles sail down from distant mountains, and make their homes upon the trees; grouse feed on the pine-nuts, and birds and beasts have a home from which they rarely wander to the desert lands below. Among the buttes on the lower terraces rattlesnakes crawl, lizards glide over the rocks, tarantulas stagger about, and red ants build their play-house mountains. Sometimes rabbits are seen, and wolves prowl in their quest; but the desert has no bird of sweet song, and no beast of noble mien.

THE TOOM'-PIN WU-NEAR' TU-WEAP'.—We now proceed to the discussion of Stillwater Cañon, Cataract Cañon, and Narrow Cañon, and the region of country adjacent thereto.

At the head of Stillwater Cañon the river turns to a more easterly

course, and runs into a fold, which has a northeast and southwest axis, but its central line is never reached. Before coming to it the river turns again to the west, and runs entirely out of the fold, at the mouth of the Dirty Devil River. It will thus be seen that the dip of the formations under discussion is to the northwest. Going down to the middle of Cataract Cañon, we constantly see rocks of lower geological position appearing at the water's edge; and, still continuing from that point to the foot of Narrow Cañon, the same beds are observed in reverse order; that is, we see at the water's edge rocks of later geological age.

Where the upturned axis of this fold is situated is not known; but, looking away to the southeast, mountains are seen—the Sierra La Sal and Sierra Abajo. Looking over the general surface of the country, it appears that the course of the river is from lower into higher lands, and then back again. Observing the present topographic features of the country, it seems strange that it did not find its way directly across from the foot of Labyrinth to the foot of Narrow Cañon, following the low lands. Why should it leave this low region, and run away out into the slope of a system of mountains, and then return? We must remember that the river is older than the mountains and the cliffs. We must not think of a great district of country, over which mountains were piled, or built, or heaved up, and that when rain fell it gathered into streams along the natural depressions of such a country, and thus attempt to account for the course of the river; but we must understand that the river cut its way through a region that was slowly rising above the level of the sea, and the rain washed out the valleys, and left rocks and cliffs standing, and the river never turned aside from its original course to seek an easier way, for the progress of uplifting was not greater than that of corrasion. Again we see how slowly the dry land has emerged from the sea; no great convulsion of Nature, but steady progress.

The Orange Cliffs, which terminate Labyrinth Cañon, extend to the west a few miles, and then change their course to the southwest, running parallel with the axis of the fold we are now discussing, and they cross the Dirty Devil a few miles above its mouth. Thus they are seen, like the other lines of cliffs, to face the axis of a fold. Fig. 2 is a bird's-eye view of this country, showing the course of the river through Stillwater, Cataract, and Narrow Cañons. It represents the cutting of the stream into the slope of a mountain-range, and out of it again, without crossing the range. On the left it shows two lines of cliffs. Here we have a district inclosed within Titanic walls. On the southeast are great mountains, and from the foot of their slope, on the north side, near Grand River, we find a line of cliffs crossing this stream, and extending to the Green, in a westerly direction; then to the southwest, to the Dirty Devil River, and then broken and confused by buttes and cañon-walls, which extend toward the east, until it

strikes the southern foot of the mountains. Within this walled area a profound gorge—Cataract Cañon—is seen, with Stillwater Cañon above, and Narrow Cañon below. The lower cañon of the Grand is also seen, and a number of lateral cañons.

Along the general slope of the district between the cañons are vast numbers of buttes. Their origin is the same as that of the buttes previously described. Often they are but monuments, or standing columns of rocks. From them is derived the Indian name *Toom'-pin Wu-near' Tu-weap'*—"the Land of Standing Rocks."

Adjacent to the larger cañons, especially near the junction of the Grand and Green, walled coves are found. Each main gulch branches into a number of smaller gulches above, and each of these smaller gulches heads in an amphitheatre. The escarpments of these amphitheatres are broken and terraced, and in many places two such amphitheatres are so close together that they are separated only by a narrow gorge of vertical homogeneous sandstone.

This latter, though homogeneous in general structure, is banded with red and gray, so that the walls of the amphitheatres seem painted. In many places these walls are broken, and the coves are separated by lines of monuments. Where these coves or amphitheatres are farther apart, the spaces above are naked, presenting a smooth but billowy pavement of sandstone, in the depressions of which are many water-pockets, some of them deep, preserving a perennial supply; but the greater number so shallow that the water is evaporated within a few days after the infrequent showers.

In many places, especially in the sharp angles between gulches, the rocks are often fissured, and huge chasms obstruct the course of the adventurous climber.

These cañons, and coves, and standing rocks, and buttes, and cliffs, and distant mountains, present an *ensemble* of strange, grand features. Weird and wonderful is the *Toom'-pin Wu-near' Tu-weap'*.

Marble Cañon.—The escarpment, which we call the "Vermilion Cliffs," at the foot of Glen Cañon, exposes the same beds as are seen in the face of the Orange Cliffs, at the foot of Labyrinth Cañon. It will be remembered that the beds exposed in the Terrace Cañons dip to the north. Between the Orange Cliffs and the Vermilion Cliffs, the strata are variously dipped by monoclinal folds, having their axes in a northerly and southerly direction, and the red beds are at about the same altitude above the sea at the two points. The Vermilion Cliffs which face the south form a deep, reëntering angle at the mouth of the Paria. On the east side of the Colorado, the line stretches to the southeast for many miles; on the west side, it extends, in a southwesterly direction, about fifteen miles, then turns west, and, at last, to the northwest. The general northerly dip is again observed from the mouth of the Paria to the mouth of the Colorado Chiquito.

The general surface of the country between the two points is the

FIG. 3.—BIRD'S-EYE VIEW OF MARBLE CAÑON FROM THE VERMILION CLIFFS, NEAR THE MOUTH OF THE PARIA. In the distance the Colorado River is seen to turn to the west, where its gorge divides the Twin Plateaus. On the right are seen the Eastern Karbab Displacements appearing as folds, and farther in the distance as faults.

summit of the Carboniferous formation. At the mouth of the Paria this is at the water's edge; at the mouth of the Colorado Chiquito it is 3,800 feet above the river. The fall of the river, in the same distance, is about 600 feet, so that the whole dip of the rock between the two points is about 3,200 feet. The distance, by river, is sixty-five miles; in a direct line, twenty miles less. So we have a dip of the formation of 3,200 feet in forty-five miles, or about seventy feet to a mile.

The slope of the country to the north is the same as the dip of the beds, for the country rises to the south as the beds rise to the south.

Stand on the Vermilion Cliffs, at the head of Marble Cañon, and look off down the river over a stretch of country that steadily rises in the distance until it reaches an altitude far above even the elevated point of observation, and then see meandering through it to the south the gorge in which the river runs, everywhere breaking down with a sharp brink, and in the perspective the summits of the walls appearing to approach until they are merged in a black line, and you can hardly resist the thought that the river burrows into, and is lost under, the great inclined plateau.

A POPULAR VERDICT.

THE life of Robert Knox, the celebrated Edinburgh anatomist, written by his friend and pupil Dr. Lansdale, is a work of much interest on account of the contributions to science made by that remarkable man; but there were some tragic features in his career which, taken in connection with the stupid and brutal "public opinion" of which he was made the victim, have an instructiveness of a quite different kind, yet of such importance that it is desirable they should not be forgotten. We can give here but a very imperfect sketch of the case, and would refer curious readers to Dr. Lansdale's book, from which we condense the following statement, making free use of the language of the author.

ROBERT KNOX, who is numbered among the descendants of the sturdy Scotch reformer, was born in 1791. He was educated at the High-School of Edinburgh, which boasted of many great names, such as Brougham, Horner, and Cockburn, in the long roll of its illustrious alumni. But few of its students showed more brilliant parts than young Knox, who rose, apparently without effort, to the head of every class, and came out gold-medalist in 1810. He joined the medical classes of Edinburgh the same year, but pursued a broad course of literary, historical, and scientific studies, together with those bearing more immediately upon the medical profession. He early took a prom-

inent place as a student of large acquirements, and twice occupied the presidential chair of the Royal Physical Society before his graduation. On his first examination for the M. D., Knox was "plucked" in anatomy. Thrown upon his metal by this untoward circumstance, he took hold of the subject so thoroughly that he became profoundly interested, was captivated by it, and chose it as the work of his life. He became an able physician and surgeon, and was sent to Brussels by the government, to render aid to the wounded of Waterloo. He joined the army in 1817, and spent three years in Africa engaged in hospital-practice. But, with a capacity for wide observation, he occupied himself with physical geography and meteorology, and more especially with natural history and ethnology. He collected and dissected specimens from every division of the animal kingdom; but man being his chief study, he took every opportunity of dissecting the natives whose bodies fell in his way through the contingencies of war; and thus added much to what was known of their peculiar anatomical characters and physiological traits. He was a skillful horseman, an intrepid hunter, and an excellent shot. Long after his sojourn among the colonists of the Cape of Good Hope, he was remembered with admiration, and spoken of as a man of transcendent abilities and accomplishments. He returned to England in 1820, and, after receiving the thanks of the army medical department for his "industry, zeal, and talents," he got leave of absence for a year, to study in the medical schools of the Continent. In Paris he made the acquaintance of Cuvier, De Blainville, Larrey, and St.-Hilaire; and to the views of the latter on the higher anatomy he became a convert. A man of great industry and originality, he produced memoirs on a wide range of subjects, which were published in the Transactions of various societies.

In 1824, Dr. Knox submitted to the Edinburgh College of Surgeons a plan for the formation of a museum of comparative anatomy, which was accepted; the scientific arrangement and active management of the establishment devolving upon the proposer. He purchased Sir Charles Bell's collection for £3,000, and brought it from London to Edinburgh. He was conservator of the museum thus formed, and classified, catalogued, and extended the collection, so as to make it most valuable for anatomical, surgical, and pathological students. After seven years' work, he left it one of the most extensive and valuable collections in Europe.

Edinburgh was at that time a prominent centre of medical study. The fame of its professors drew crowds of students to the university. But the teaching of anatomy was mainly an outside affair; that is, it was conducted in private institutions, independent of the university. Several eminent anatomists had lectured to preparatory classes in these schools, and in 1825 the leading man in this field was Dr. John Barclay, a thorough anatomist and accomplished lecturer, who had a large class of students. Dr. Barclay was the author of many valu-

able anatomical works; and in illustration of his character it may be mentioned that one day Henry Brougham, afterward Lord Brougham, then on the staff of the *Edinburgh Review*, asked the doctor to give him half an hour's talk on anatomy, to enable him to write a critique on one of his (Barclay's) books. This is a fair sample of the capital on which the noble quack earned his scientific reputation. The anatomist refused the request and resented the impertinence. Dr. Barclay was, however, getting old, and he formed a partnership with Knox in the management of the school. He soon after died, and Dr. Knox became master of the establishment. He at once rose to unexampled popularity. In the first place, he was a man of profound, comprehensive, and thorough erudition. Anatomy was not with him a mere ordinary occupation, but an object of high philosophical research, and pursued with enthusiasm. He was early to recognize the two divisions—anatomical science and anatomical art—the former embracing the elucidation of the nature or structure and organization of animal bodies; the latter comprehending all those means and contrivances by which organisms can be dissected and demonstrated. He was one of the first of philosophic biologists. When he began to teach, human anatomy was treated very much as a superficial and technical pursuit, to be dispatched in a three months' course of dissections, by the majority of medical students. To some lecturers, a bone was a structure with certain physical features, and nothing more. Knox made it assume an historical position in the scale of organization; its size and form were obvious enough, but he sought in the osteogenesis, type, and homologues, to fix its place in the general superstructure of the animal series. In short, he gave not the mere description but the philosophy of the osseous form. "There was no circumlocution in his teachings; he aimed at a clear delineation of the work before him. He was more practical than minute, more suggestive than analytic in his systematic course; rather than linger on points of detail, he indicated the path to be pursued by the student. His mode of teaching was not suited to the 'grinding' or 'cramming' system; hence those who sought anatomy for examining boards went elsewhere. His prelections were well adapted to stimulate thought, as he meant them to do. Being a surgeon and pathologist, Knox could significantly apply anatomy to a practical calling; and as a physiologist of high aim, he looked to zoölogy as a *sine qua non* to the study of the higher philosophy of man himself."

Dr. Knox was an orator of the first class, a tight-made man, above the middle stature, of the nervo-sanguineous temperament, broad-chested, with an upright carriage, a firm and soldierly walk, and a free and lithesome action. He had a strikingly fine head, but a plain visage, an agreeably-toned voice, and a persuasive tongue that made captive every listener who could appreciate colloquial excellence. He had a weakness for elegance of dress, and attended carefully to all

the arts by which an audience can be fascinated; but he never lost his suave demeanor and high respect for his class as a body of gentlemen. His movements were graceful, and his gestures, now slow and now rapid, had a rare felicity and pertinence to the matter in hand. His style, his illustrations, and insinuating speech, lent a marvelous fascination to his subject, and he stood before his class the impersonation of lofty intellect and perfect self-possession. He was an ideal lecturer. The area of his class-room was to Knox a charmed circle. There he exercised a weird influence that traversed from side to side the thronged benches and subtly pervaded the mind of every member of his audience.

As a consequence of these traits, of the solidity and breadth of his knowledge, and of the consummate art of his delivery, Dr. Knox was to an extraordinary degree popular with his classes. At all times accessible and ready to offer kindly and encouraging counsel, he became the "guide, philosopher, and friend," of every worthy student. His pupils loved him and lauded him to the skies, and his anatomical classes were larger than any other ever assembled in Britain. Country physicians rode twenty miles to attend his introductory lectures. "The benches of Knox's class-room were occupied by a scholarly, earnest, and appreciative class; the majority were strictly medical students, but mingling with these were English barristers, Cambridge scholars and mathematicians, Scottish advocates and divines, scions of the nobility, artists, and men of letters. The zoölogists and naturalists flocked to Knox for their comparative anatomy. General students looked upon him as the great master of his art, and fully indorsed the encomiums bestowed upon him by Audubon and others of still greater eminence, both Continental and Transatlantic. Military and naval surgeons, in active service or on half-pay, often mingled with the crowd. Cultivated men of all kinds were attracted by his fame, and looked upon his instructions as the greatest intellectual treat afforded them in the modern Athens; while among his students it was remarked that the higher their intellectual grade, the more profound was their admiration of his genius and their personal attachment to him."

As an indication of how Dr. Knox was regarded by his class, his biographer states: "There was a struggle to obtain good places in Knox's lecture-room each day at eleven o'clock. The first year's students attending chemistry, and the second year's men attending surgery, between the hours of ten and eleven, were the chief claimants for Knox's front seats. The university, from whose class-rooms the majority of Knox's men came to hear his morning lecture, was about three minutes' walk from Old Surgeons' Hall—Knox's place. The competitors in their flight down two staircases, from Hope's Chemistry Rooms, their racing across the quadrangle of the university, their sweeping rush over every obstacle to gain Infirmary Street,

offered an exciting spectacle. The race was neck and neck, and woe betide whoever fell in the way! Old and young passers-by were thrown down in the *mêlée* caused by scores of agile-limbed fellows contending for the Knox goal. The rare and intense enthusiasm that Knox created in his class belongs to the past; no such high fervor is manifested by the student of these latter days. The reason is obvious: he who called it forth is gone, and his counterpart is nowhere to be found; indeed, it is more than doubtful if another Knox will ever appear before a British audience. Old pupils of Knox, both privately and publicly, still speak with sparkling eyes of the grand excitement and rush for favored seats in his lecture-room."

Robert Knox was, moreover, a hater of all humbug, and an unsparing critic of shams of every sort. He ridiculed the superficial method of teaching anatomy practised by rival lecturers, and in his sudden bursts of oratory, his sharp, pithy sentences, which came like sparks from a furnace, often created havoc among doubtful medical reputations, and his telling sarcasms would often circulate through Scotland. It was therefore impossible that he should not make many enemies. His very eminence and popularity also could not fail to be a source of hostility on the part of the envious and jealous. Often his class seemed spellbound under the influence of a speech; and as he wound up his lecture with increasing emphasis, and a sweeping torrent of rhetoric, and bowed his exit, the crowded audience would often rise *en masse*, waving their hats and handkerchiefs, and cry: "Bravo! bravo! Knox forever, and one cheer more!" All this was delightful; but, as this world is constituted, men often have to pay dearly for such things; and so did Dr. Knox.

Anatomy is the foundation of surgery, and the basis of all rational medical science. To know the structure of the human organization is indispensable both to the progress and the intelligent practice of the healing art. A knowledge of anatomy is therefore the first condition of the most important and beneficent of all occupations—that of alleviating human suffering and saving human life. But the knowledge of the human body that is necessary to remedy its diseases cannot be obtained except by studying it through and through; and this can only be done when the corporeal fabric becomes useless for other purposes. Dead bodies, worthless for any thing else, are invaluable for dissection, and if dissected they must of course be obtained for the purpose. Yet, with an absurd inconsistency, governments, while exacting of medical students a knowledge that can only be procured by the dissection of corpses, have at the same time outlawed the procurement of subjects. Such has been the policy of states for centuries, and in pursuing it the civil power has but given expression to one of the profoundest prejudices and most wide-spread superstitions of human nature. Antipathy to dissection after death is a deeply-rooted

feeling that has been manifested by all nations, creeds, and peoples—Egyptian, Greek, Roman, Mohammedan, Christian, and Jew. The primitive Christians, as evinced by their epitaphs, cursed the disturbers of their remains in the Roman Catacombs. When science was regarded as little else than magic, and diseases were ascribed to the influence of the devil, physicians were looked upon as sorcerers, and it was but natural that those who considered that their bodies were destined to resurrection should entertain a hatred and horror of those who would cut it up in the dissecting-room for base purposes of utility. And when governments in modern times began to concede a restricted privilege of dissection, the mode of doing it only served to heighten the horror with which the operation was popularly regarded. For three centuries the law increased the infamous reputation of dissection by making it follow the work of the gallows. These feelings were peculiarly intense in theological Scotland, so that the modern medical schools had the greatest difficulty in getting even a few subjects for anatomical study. The necessity of having them, however, created a special craft of body-snatchers and robbers of graveyards. Nothing was more calculated to infuriate the populace than to discover that a grave had been violated. The church-yard was a sacred precinct, "God's acre," and the removal of a body from it was treated as an impious interference with the plans of Providence respecting the great resurrection—the body-stealers being accordingly named "resurrectionists." The men who took to this vocation were of the lowest and most brutal sort. None but base and desperate rascals, indifferent to public detestation, would pursue a business so reprobated by all classes, and so the very quality of the men added repulsiveness to the occupation. Yet physicians were constantly compelled to coöperate with these wretches; that is, to buy their plunder and keep their secrets, as the very first condition of sound medical education. But government, with its legal enactments, joined the superstitious masses in arresting the work of anatomy and making it unlawful and impracticable. The physicians petitioned the authorities for relief, and were answered with more stringent enactments, prosecutions, and spies and detectives watching the doors of medical schools. These schools in Edinburgh were sacked by mobs or starved into suspension by the impossibility of obtaining subjects. "The law virtually proclaimed that the surgeon should possess aptitude and skill as well as a formal license to practise; nay, it went further, and subjected him who failed to display proper skill to pecuniary forfeiture in the civil courts at the instigation of any dissatisfied patient; yet the only mode of acquiring that skill—namely, from dissections of the dead clandestinely obtained—was in the criminal court held to be a misdemeanor, punishable by fine and imprisonment."

Such was the state of things in Edinburgh when Dr. Knox entered upon the public teaching of anatomy. With the unprecedent-

ed enlargement of his classes, which sometimes rose to more than five hundred students; and with his thorough-going views of the importance of actual dissection to the well-prepared physician, the demands of his establishment for subjects were necessarily large. These he had, of course, to meet in various ways. The home supply of bodies being insufficient, he made arrangements with distant places in England and Ireland to have subjects sent to Edinburgh. He was often compelled to pay so high for cadavers that it consumed the profits of his teaching, and in one session he lost nearly $4,000 from this cause alone. An enthusiast himself, and with an enthusiastic class, he could not endure to see the bare dissecting-tables, or to hear the importunate solicitations of his students seeking for professional opportunities that were denied them away from a medical school. Not infrequently the professors of medical colleges have joined the resurrectionists in their midnight adventures, or have pursued them alone; and many thrilling stories are recorded of their nocturnal exploits in getting possession of subjects which offered special interest to the anatomists. But Dr. Knox never indulged in these practices. He despised the resurrectionists whom he was compelled to use, and did his best to get a change of legislation by which anatomy might be prosecuted in a legal and legitimate way. Failing to secure this, he had to resort to the usual expedients for facilitating anatomical study—expedients as old as medical science.

On the 29th of November, 1827, an old man by the name of Donald died in West Port, one of the purlieus of Edinburgh. He lodged with an Irishman named William Hare, and died owing him four pounds. His creditor saw but one way of reimbursing himself, and that was by disposing of the old man's body to the doctors. Hare found a ready accomplice in William Burke, another Irishman, and also one of his lodgers. The body was removed from the coffin, and a bag of tanner's bark substituted for it. The lid was screwed down and the little funeral went off as usual. The same evening, Hare and Burke stealthily repaired to the university, and, meeting a student in the yard, asked for the rooms of Dr. Monroe, the Professor of Anatomy. The student happened to be a pupil of Knox's, and, upon discovering their errand, he advised them to try Knox's place in Surgeons' Square. There they sold the body for £7 10*s*., a large sum for them, and very easily obtained. They had not courage to go into the regular business of body-stealing; and so Hare, the vilest of the two, suggested a fresh stroke of business, which was to inveigle the old and infirm into his quarters and "do for them." Hare started in search of a victim; and, prowling through the slums, met an old woman half drunk, and asked her to his house. He gave her whiskey until she became comatose, and then with Burke's assistance strangled her. The body brought £10.

The appetite of the vampires was now sharply whetted, and they entered systematically upon the work of murder. Vagrants, street-walkers, and imbeciles, were allured on various pretexts to the house of Hare, made dead drunk, and suffocated. Emboldened by their successes, they began to pursue their thuggish practices even in daylight. A woman named Docherty was stifled, and her body left half-exposed under some straw was seen by two lodgers, who notified the police. Thirteen victims had been secured in eleven months, and all taken to the same place and sold. The prisoners were tried December 24, 1828, when Hare, the blackest of the villains, was let off by turning "state's evidence," and Burke was convicted, hanged, and dissected.

The effect produced upon the public by this horrible disclosure is indescribable. A new and unheard-of crime, that of "Burking," was added to the list of atrocities of which human fiends are capable. Astonishment and terror spread through the community. Households gathered their members within-doors before dusk; workmen walked home from their night's toil in groups, as if in fear of being waylaid. The facts were appalling enough; but a thousand exaggerations and inventions filled the air, and intensified the universal excitement.

It could hardly be expected that public feeling, under such circumstances, would be restrained within the bounds of reason, but it went to the most outrageous excesses. Those who were loudest in their execrations of Hare and Burke, were themselves guilty of conduct almost as atrocious, which was nothing less than the endeavor to fasten the turpitude of these crimes upon the parties at the Medical School who received the bodies. They were accused of being in collusion with Hare and Burke, of conniving at their villainy, and paying them the wages of murder. Dr. Knox, who was at the head of the establishment, was held responsible, and accused of being the prime mover of the dark transactions.

Yet Dr. Knox never saw Burke and Hare but twice during the whole time that they were bringing subjects to the institution, and never had any thing whatever to do with them. The subjects were received in the usual way by persons in charge of the dissecting-room, and they constituted less than one-sixth of the regular supply of the establishment. Moreover, the practice of obtaining subjects in the way they were alleged to come had been long pursued. Tramps, vagabonds, beggars, and worthless, homeless creatures of all sorts were dying in the hovels, dens, cellars, and gutters, with nobody to claim them, and even their relatives, if they had any, would often sell their bodies for a few bottles of whiskey. It was frequently necessary in crowded lodgings to have bodies promptly removed, and there was a regular business done with the medical colleges in smuggling this class of subjects into their rooms. Hare and Burke were therefore doing nothing apparently unusual or that in itself excited suspicion. The porter of the establishment received the bodies, deposited them in the mor-

tuary, and then reported to the assistants, who were young medical students, without long experience. It was alleged that the bodies were brought fresh and warm, which was proof enough of the way they had been obtained. But this was by no means a necessary conclusion. Some of Burke's contributions were fresh, which created surprise; but he made no secret that he was in league with the relatives of the deceased or the owners of lodging-houses, for the prompt possession of bodies as soon as life was extinct. "When his attention was drawn to two apparently newly dead, his glib tongue and plausible statement served his purpose so well as to lull all doubts. One of these bodies was warm, on touching which the assistant expressed himself much horrified. Burke, being challenged in the strongest terms, admitted the warmth, for the person died only a few hours previously, and for secrecy the body had been in close contact with the fireplace. His open manner and ready excuse, when so boldly taken to task, told strongly in favor of the accuracy of his statement."

To illustrate the facility with which irregular practices might be carried on without public interference, Dr. Knox's biographer remarks: "There are no coroners' inquests in Scotland. Sudden death of either stranger or citizen does not concern the public authorities, unless suspicion is entertained and evidence can be offered to warrant the attention of the procurator-fiscal, who then makes a most thorough investigation in private, untrammeled by stupid juries and the comments of the press." He adds: "With the exception of Episcopalians and Roman Catholics, there is no burial service, either at the church or at the grave-side, in Scotland. In lieu of this, a minister attends the funeral, who offers a prayer or makes an address by the side of the bier at the house of the deceased." This gave rise to mock or sham ministers. Hypocritical wretches palmed off their services in many cases among the poor and ignorant to conduct funerals, and managed them so as to play into the hands of the body-snatchers.

The history is a peculiar one, and would require a volume to trace its complications. But the main fact about it is, that the doctors stood in peculiar relations, which exposed them to public animosity, and put them to every disadvantage, when the most extravagant and futile charges were made against them. A revolting and inhuman crime had certainly been committed, and the Medical School had the benefit of it. The conclusion that the head of the school had instigated it was easy to draw, especially if there was the slightest inclination of unfavorable feeling toward him.

Dr. Knox had therefore now to pay the penalty of his popularity. There was a vast mass of indignant and exasperated feeling in the university ready enough to be hostile, and easily turned in the direction of accusation and reprobation. The enemies of Dr. Knox, those who had been irritated by his comments, and those who were jealous of his influence, seized the opportunity to pay him off. It mattered

little that there was neither evidence nor shadow of evidence of the charge: it was only necessary to link Dr. Knox's name with the atrocities, and reasons enough would be found for the belief that he was the cause of them. If it appeared incredible, the reply was, that the villainies had actually been perpetrated by *somebody*, then why not instigated by him who had the greatest interest in the result? Besides, he was none too good for it, as judged out of his own mouth. Had he not replied to a medical student, when asked how he came to have so many Kaffre skulls in his museum: "Why, sir, there was no difficulty in Kaffraria; I had but to walk out of my tent and shoot as many Kaffres as I wanted for scientific and ethnological purposes." A passing joke was thus tortured into proof of a murderous disposition, and had its numerous believers. Again, Dr. Knox had said that "he could always command subjects." To which it was rejoined, "We now know what he meant—the West Port villains were in his pay." Thus by insinuation, perversion, and hinted suspicion, on the part of those who ought to have known better, and by a gaping credulity on the part of the mass of the people, the charges against Dr. Knox came to be believed by bare force of reiteration and association of ideas. The following specimen of the literature of the time embodies the whole logic of the case:

"Down the Close, and up the Stair,
But and Ben wi' Burke and Hare.
Burke's the butcher, Hare's the thief,
Knox the man that buys the beef."

On no better grounds than this Dr. Knox was condemned by the press, slandered by his medical brethren, denounced by the clergy, and his life was sought by the mob. Relying upon his entire innocence, abhorring the crime that had been done as much as anybody, and deeply indignant at the charges that were brought against him, Dr. Knox preserved silence. We can now appreciate the dignity and self-respect which impelled him to this, but he calculated wrongly for himself. Silence cannot be comprehended by a stupid public or a clamorous mob. The people were infuriated that he had not been indicted along with the West Port murderers, and Knox had to bear the whole weight of the city's wrath, which was increased by covert enemies in every quarter, and still further heightened by the escape of Hare. "Two months after Burke's condemnation, and his confession exonerating Knox from all blame whatsoever had been given to the world, *Blackwood's Magazine*, in its 'Noctes Ambrosianæ' (March, 1829), written by John Wilson, Professor of Moral Philosophy in the University of Edinburgh, *alias* Christopher North, made every effort to blast the character of the anatomist. Literary ruffianism is too mild a term to apply to the foul words used by Wilson, who, not content with holding up Knox to public execration, rushed with the savagery of the war-whoop and tomahawk upon an unoffending

anatomical class, for showing an affectionate regard for their great teacher."

Dr. Knox could have brought his enemies to strict account, and obtained heavy damages for their foul libels, but he preferred the policy of forbearance, as he had that of silence, and to leave the matter to be determined when the excitement should cease. So he kept on steadily with his work. One night, when a large class had assembled to hear him, the proceedings were interrupted by the yells and threats of an outside crowd, so that the students became alarmed. Knox, perceiving the growing restlessness of the audience, paused, and remarked: "Gentlemen, you are disquieted by these noises, to which no doubt you attach a proper meaning. Do not be alarmed; it is my life, not yours, they seek. How little I regard these ruffians you may well judge, for, in spite of daily warnings, and the destruction of my property, I have met you at every hour of lecture during the session; and I am not aware that my efforts to convey instruction have been less clear or less acceptable to you." This statement was received with such cheers as never before rang through a class-room in Edinburgh; and, amid all his troubles and trials, he found his only solace in the approval and affection of his students.

Dr. Knox at length broke his long silence by a letter to the *Caledonian Mercury*, of which the following is a part:

"Sir: I regret troubling either you or the public with any thing personal, but I cannot be insensible of the feelings of my friends, or the character of the profession to which I have the honor of belonging. Had I alone been concerned, I should never have thought of obtruding on the public by this communication.

"I have a class of above 400 pupils. No person can be at the head of such an establishment, without necessarily running the risk of being imposed upon by those who furnish the material of their science to anatomical teachers; and, accordingly, there is hardly any such person who has not occasionally incurred odium or suspicion from his supposed accession to those violations of the law, without which anatomy can scarcely now be practised. That I should have become an object of popular prejudice, therefore, since mine happened to be the establishment with which Burke and Hare chiefly dealt, was nothing more than what I had to expect. But, if means had not been purposely taken, and most keenly persevered in, to misrepresent facts and to influence the public mind, that prejudice would at least have stood on right ground, and would ultimately have passed away, by its being seen that I had been exposed to a mere misfortune, which would almost certainly have occurred to anybody else who had been in my situation.

"But every effort has been employed to convert my misfortune into positive and intended personal guilt of the most dreadful character. Scarcely any individual has ever been the object of more systematic or atrocious attacks than I have been. Nobody acquainted with this place requires to be told from what quarter these have proceeded.

"I allowed them to go on for months without taking the slightest notice of them; and I was inclined to adhere to this system, especially as the public

authorities, by never charging me with any offense, gave the only attestation they could that they had nothing to charge me with. But my friends interfered for me. *Without consulting me*, they directed an agent to institute the most rigid and unsparing examination into the facts. I was totally unacquainted with this gentleman; but I understood that, in naming Mr. Ellis, they named a person whose character is a sufficient pledge for the propriety of his proceedings.

"The result of his inquiries was laid before the Dean of Faculty and another counsel, who were asked what ought to be done. These gentlemen gave it as their opinion that the evidence was completely satisfactory, and that there was no want of actionable matter, but that there was one ground on which it was my duty to resist the temptation of going into a court of law. This was, that the disclosures of the most innocent proceedings even of the best-conducted dissecting-room must always shock the public, and be hurtful to science. But they recommended that a few persons of undoubted weight and character should be asked to investigate the matter, in order that, if I deserved it, an attestation might be given to me, which would be more satisfactory to my friends than any mere statements of mine could be expected to be.

"After a severe and laborious investigation of about six weeks, the result is contained in the following report, which was put into my hands last night. . . .

"Candid men will judge of me according to the situation in which I was placed at the time, and not according to the wisdom which has unexpectedly been acquired since. This is the very first time that I have ever made any statement to the public in my own vindication, and it shall be the last. It would be unjust to the authors of the former calumnies to suppose that they would not renew them now. I can only assure them that, in so far as I am concerned, they will renew them in vain."

The report here referred to bore the names of Sir John Robinson, chairman; Mr. M. P. Brown, advocate; Prof. James Russell, Dr. Alison, Sir George Ballingall, Sir George Sinclair, Sir William Hamilton, and Mr. Thomas Allen, banker; and completely and absolutely exonerated Dr. Knox from the charges that had been made against him. The public advocate went to the bottom of the case, and declared that there was no ground of suspicion; and one of the ablest representatives of the British bar, Lord Cockburn, who had a personal knowledge of all the facts, wrote in the "Memorials of his Time" as follows: "All our anatomists incurred a most unjust and very alarming though not unnatural odium; Dr. Knox in particular, against whom not only the anger of the populace, but the condemnation of the more intelligent persons, was specially directed. But, tried in reference to the invariable and the necessary practice of the profession, our anatomists were spotlessly correct, and Knox the most correct of them all."

Dr. Knox was a man of pluck, and he went along about his business, paying little attention to the storm of abuse and vituperation that rained upon him. But the savage injustice of which he was a victim was, nevertheless, not without its effect. It clouded his prosperity, darkened his life, and gave a cynical turn to his disposition.

His biographer remarks: "Only once, as far as I can learn, did Knox exhibit any emotion on account of the connection of his name with the Burke and Hare atrocities, and his freely-alleged complicity in the transaction. Walking in the meadows at Edinburgh with his old friend Dr. Adams, their conversation turned upon 'outward form and its relation to inward qualities.' Knox had a keen appreciation of the beautiful in form; and it chanced at the moment that a pretty little girl, about six years of age, caught his notice while at play. She afforded a text for Knox's comment on physical beauty, combined with unusual intelligence, in so young a child, for by this time he had drawn her into a playful conversation. At length he gave her a penny, and said: 'Now, my dear, you and I will be friends. Would you come and live with me if you got a whole penny every day?' 'No,' said the child; 'you would, maybe, sell me to Dr. Knox.' The anatomist started back with a painfully stunned expression; his features began to twitch convulsively, and tears appeared in his eyes. He walked hastily on, and did not exchange words with Dr. Adams for some minutes; at length came a forced laugh, with a questionable emphasis on the words '*vox populi*,' which led to a new topic of discourse."

Dr. Knox gave up his lectures in Edinburgh in 1839, and afterward went to London, where he died, December 20, 1862.

TEMPERED GLASS.

By PERRY F. NURSEY, C.E.

A CONSIDERABLE degree of well-merited attention has of late been directed toward an invention which may be justly termed remarkable, even in these days of startling discoveries, inasmuch as it is one which promises to effect a complete change in the physical character of glass. This invention is the toughening process of M. François Royer de la Bastie, by which the natural brittleness of ordinary glass is exchanged for a condition of extreme toughness and durability. And this invention is perhaps the more remarkable in that it does not emanate from one engaged in, or practically conversant with, the manufacture of glass; nor is the discovery due to one of the great lights of science of our day; neither was it the result of a happy momentary inspiration. On the contrary, M. de la Bastie is a French private gentleman of fortune, residing in his native country—who, however, is given to the study of scientific matters. He was educated as an engineer, but his position and means rendered it unnecessary for him to follow the profession into which he had been initiated. He, however, is fond of experimenting in matters relating to engineering, and among

other things he, some years since, conceived the idea of rendering glass less susceptible to fracture, either from blows or from rapid alternations of heat and cold. The early training of his mind naturally led him to look to mechanical means for the accomplishment of this end; and he, in the first place, set himself a purely mechanical problem to solve. He thought—as did Sir Joseph Whitworth with regard to steel—that by submitting glass when in a soft or fluid condition to great compressive power, he should force its molecules closer together, and, by thus rendering the mass more compact, the strength and solidity of the material would be greatly increased. This was not an unreasonable line of argument, inasmuch as the fragility of glass results from the weakness of the cohesion of its molecules. Success, however, did not follow experiment, and the mechanical problem was laid aside unsolved.

M. de la Bastie, however, continued to regard the question from an engineering point of view, and turned his attention to another method of treatment. Aware that the tenacity of steel was increased and that a considerable degree of toughness was imparted to it by dipping it, while hot, into heated oil, he experimented with glass in a similar manner. The results were sufficiently successful to encourage him to persevere in this direction, and, by degrees, to add other fatty constituents to the oil-bath. Improved results were the consequence; and they continued to improve until at length, after several years of patient research and experiment, De la Bastie succeeded—with a bath consisting of a mixture of oils, wax, tallow, resin, and other similar ingredients—in producing a number of samples of glass which were practically unbreakable. As may be supposed, there were other conditions upon which success depended besides the character and proportions of the ingredients constituting the bath. M. de la Bastie, not being a glass-manufacturer, purchased sheets of glass, as well as glass articles, which he heated in a furnace or oven, to a certain temperature, and transferred to the oleaginous bath, which was also heated to a given temperature. These questions of relative temperature, therefore, had to be worked out; and De la Bastie had further to determine, very precisely, the condition of the glass most favorable for the proper action of the bath upon it. This he found to be that point at which softness or malleability commences, the molecules being then capable of closing suddenly together, thus condensing the material when plunged into a liquid at a somewhat lower temperature than itself, and inclosing some portion of the constituents of the bath in its opened and susceptible pores. Having determined all these conditions, and constructed apparatus, M. de la Bastie was enabled to take ordinary glass articles, and pieces of sheet-glass, and to toughen them so that they bore an incredible amount of throwing about and hammering without breaking. Just, however, as De la Bastie had perfected his invention, he lost the clew to success, and for two years he

was foiled in every attempt to regain it. There was the hard fact staring him in the face, that he had succeeded in depriving glass of its brittleness, as shown by specimens around him; but there was the harder fact before him, that he had lost the key of his success. Nevertheless he labored on, and at the end of the period above mentioned he had the satisfaction of finding all his anxieties at an end; his toils were requited by the rediscovery of his secret. He has since worked at it most assiduously, and has now brought it into practical working order, rendering the process as certain of success as any in use in the arts and manufactures in the present day.

As already observed, M. de la Bastie is not a glass-manufacturer; he therefore had to reheat glass articles when toughening them. It, however, by no means follows that the toughening process cannot be applied in the course of manufacture, thus avoiding reheating. On the contrary, it not only can be, but has been, applied at glass-works to glass just made, and so saves the costly and time-absorbing process of annealing. But, for reasons stated, M. de la Bastie had to apply the process to the manufactured article; and the method adopted, and the apparatus used in its application, next merit attention. In the first place, the glass to be toughened had to be raised to a very high

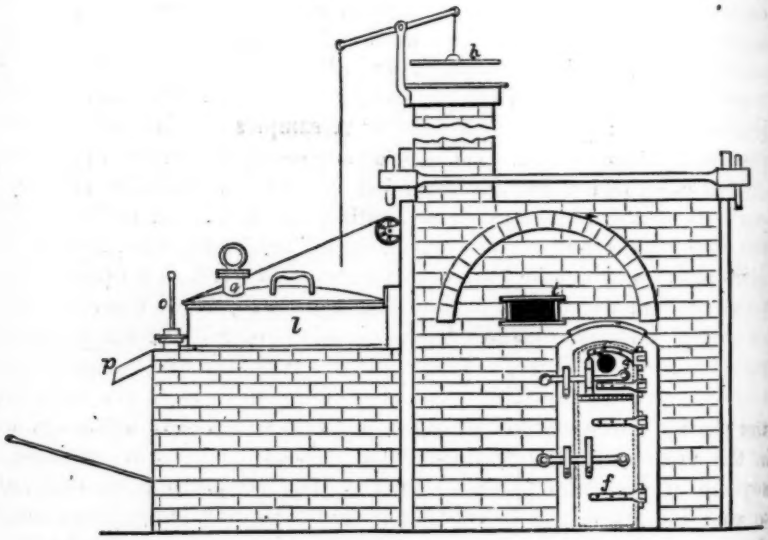


Fig. 1.

temperature—the higher the temperature the better—the risk of breaking the glass being thereby reduced, and the shrinkage or condensation being increased. It was therefore advantageous, and often necessary, to heat the glass to the point of softening; but in that condition glass articles readily lost their shape, and had to be plunged into the

bath almost without being touched. Then came another difficulty—that of preventing an already highly-heated combustible liquid taking fire upon the entrance of the still more highly-heated glass. The latter difficulty was met by placing the tempering bath in direct communication with the heating oven, and inclosing it so as to prevent access of air; and the former by allowing the heated glass articles to descend quickly by gravitation, from the oven to the bath.

The apparatus used by M. de la Bastie is shown in the accompanying illustrations, in which Fig. 1 is a front view, and Fig. 2 a vertical section, of furnace for annealing glass objects; Fig. 3 a sectional plan of the oven for annealing flat plates. The working oven, *a*, is heated by a furnace, *b*. The bottom of the oven, *c*, and the slope to the bath, are made in one piece of refractory material, and are very smooth on the surface. At the side of the oven is a preparatory oven, communicating by a passage in the separating wall. In this oven the glass is partially heated before being placed in the main oven, *a*. The products of combustion are carried away in the direction of the arrows through the chimney. When the oven, *a*, is sufficiently heated, the ash-pit and fire-doors are closed, and rendered air-tight by luting,

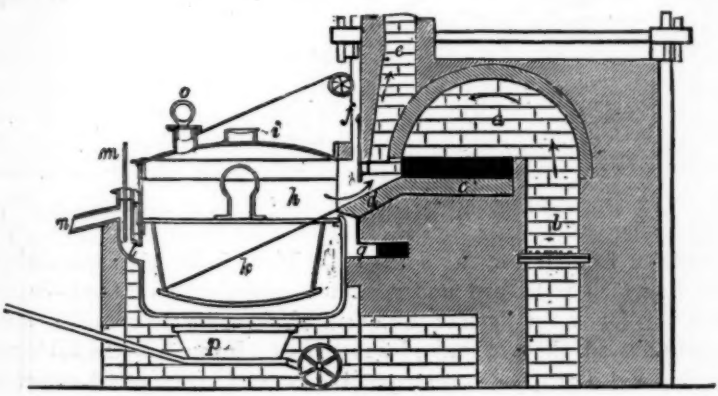


Fig. 2.

and the fire is maintained by small pieces of fuel introduced by a hole in the fire-door. The draught is then stopped by lowering the chimney-cap, or closing the damper. The vertical damper, *f*, is then raised, so that the flame passes by the flue, *g*, to a second chimney, passing thus along the slope and heating it, and also opening communication from the oven, *a*, to the bath, *h*, which is filled with the oleaginous compound. It is covered from the external air by a lid, and within it is a basket of fine wire gauze, *k*, hung from brackets. A tube, *l*, contains a thermometer, *m*, to indicate the temperature; and by this tube the contents of the bath may be added to, or any excess may overflow by the discharge-pipe, *n*. A plug, *o*, on the cover may be removed to

observe the interior, without entirely uncovering the bath. A fire-truck, *p*, charged with live fuel, heats the bath to the desired temperature. The glass is introduced into the preparatory oven by an opening in the outer wall, and thence it is moved through a second opening on to the floor of the oven, *a*. The workman who watches the glass through a spy-hole, when he finds it at the proper heat, pushes it by an iron rod to the slope, *d*, whence it slides into the bath and is received on the basket, *k*. When the glass has cooled to the temperature of the bath, the lid is removed, and the basket, *k*, is raised out of the bath with the tempered glass.

In tempering sheet-glass the arrangements of both oven and bath are slightly modified, as shown in Fig. 3. In place of the sloping exit

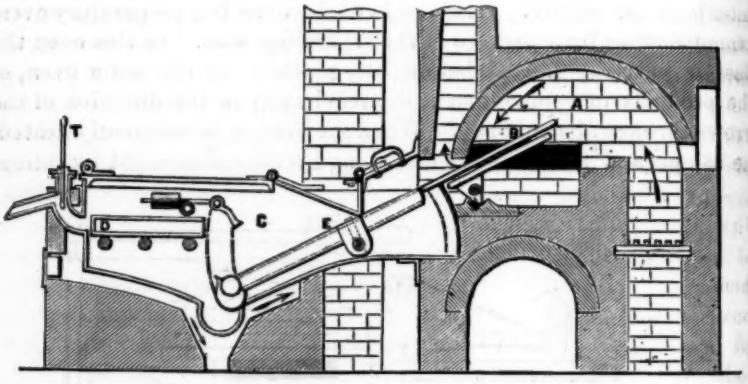


FIG. 3.

for articles from the oven to the bath, M. de la Bastie has a rocking table, E, which is hinged underneath to the mouth of the oven, and which also forms the floor of the oven. When the glass has been sufficiently heated, the workman, by means of a lever, tilts the table, and the glass slides gently down an easy incline on to a table set at a corresponding incline in the bath. If it is not of importance that the transparency of the glass should be preserved, no special precautions are taken to prevent the dust from the furnace settling on its face. Where, however, clearness is required, the glass is heated in a muffle, perfect transparency being obtained. The process of tempering or toughening, exclusive of the time required for heating the glass, occupies but a minute or so, the glass being immersed in the bath and at once withdrawn and set aside to cool. The cost per article, as may be supposed, is merely nominal.

Glass which has been treated in this manner undergoes a physical transformation as complete as it is remarkable. Its appearance is in no way altered, either as regards transparency or color—if colored glass be so treated—and its ring or sound is not in any way affected.

It has, however, exchanged its distinguishing characteristic of extreme brittleness for a degree of toughness and elasticity which enables it to bear the impact of heavy falling weights and smart blows without the least injury. A great number of experiments have been made, the results of which fully corroborate this fact. From these it will suffice to select a few by way of illustration. Watch-glasses, which perfectly retain their transparency, have resisted every attempt to break them by crushing between the fingers, or by throwing them about indiscriminately on the bare floor. Glass plates, dishes, colored lantern-glasses, and the like, have been similarly thrown about by the handful, stood upon, and otherwise maltreated, but without the slightest injury accruing to them, except, perhaps, when a solitary specimen which had been imperfectly tempered got in with the rest. Experiments have also been carried out to ascertain the comparative strength of toughened and untoughened glass when submitted to bending stress. Here a number of pieces of glass, each measuring six inches in length, by five inches in breadth, and having a thickness of about one-fourth of an inch, were tried. Each sample in its turn was supported at the ends, and a stirrup-piece was hung upon the centre of the glass, a weight-rod hanging vertically from the under-side of the stirrup. With this arrangement applied to a piece of ordinary glass, the weight-rod was gradually loaded until a weight of 279 pounds was reached, when the glass broke. A piece of toughened glass of similar dimensions, similarly treated, did not give way until a strain of 1,348 pounds had been reached, and before it yielded a considerable deflection was produced in it, showing its elasticity. Had its strength been due to rigidity or inflexibility alone, it would not have assumed a curve before yielding to the pressure brought upon it.

Satisfactory as the above results may appear at the first glance, they will be seen upon reflection most inadequately to represent the relative strength of toughened and untoughened glass. It will be observed that the test applied was that of long-sustained and gradually-increasing pressure, which could rarely occur to glass articles in every-day use. Glass is subject to sudden, sharp blows, either from articles falling down on other substances or from extraneous bodies falling upon or being brought in contact with them. Hence it is clear that to obtain a true estimate of the new process, glass must be subjected to tests which fairly represent the conditions of the accidents to which it is ordinarily exposed. This estimate has been arrived at repeatedly by placing pieces of plate-glass in a frame and allowing weights to fall on them from given heights. One experiment from a number—and which was made publicly—will illustrate this test: A piece of ordinary glass, six inches long by five inches wide, and one-fourth of an inch thick, was placed in a small frame which supported the glass around its edges, and kept its under-side about half an inch from the floor. A four-ounce weight was dropped on it from a height of one

foot, and the glass was broken. A piece of toughened glass of corresponding dimensions was then placed in the frame and the same weight dropped upon it several times from a height of ten feet, but without fracturing the glass. An eight-ounce weight was then substituted, and repeatedly dropped upon the glass from the same height as before, and with the same result, no impression whatever being made upon it. The eight-ounce weight was then thrown violently upon it several times, but without damaging it. Its destruction, however, was finally accomplished by means of a hammer. Perhaps the most crucial test to which toughened glass could be put would be to let it fall on iron. This has been done, and in public too. A thin glass plate was dropped from a height of four feet on to an iron grating, from which it rebounded about one foot, sustaining no injury whatever.

As singular as any other feature presented by toughened glass are the results of its destruction. Ordinary glass, upon being fractured, gives long, needle-shaped, and angular fragments. Not so toughened glass, which is instantaneously resolved into mere atoms. The whole mass is at once disintegrated into innumerable pieces, ranging in size from a pin's-point to an eighth of an inch in diameter. It sometimes occurs that pieces measuring half an inch or an inch across may remain whole, but these pieces are traversed in all directions by a net-work of fine lines of fracture, and with the fingers are easily reduced to fragments. Microscopical examination shows the fragments of toughened glass—large and small—to follow the same law as regards the form and character of the crystals, and on some of the larger crystals being broken up they have been found to separate into smaller ones of the same character. The edges of these fragments, too, are more or less smooth instead of being jagged and serrated as are those of fragments of ordinary glass. Hence a diminished tendency in the former to cause incised flesh-wounds when handled.

When glass has been imperfectly treated, as has sometimes happened in M. de la Bastie's experiments, it will not stand the same amount of rough usage as will perfectly-toughened specimens. The fact of the toughening process having been incomplete is made manifest upon the destruction of a sample in three different ways chiefly. Independently of its yielding at an early stage either to blows or pressure, it will show upon destruction either needle-fractures approaching in appearance those of ordinary glass, or pieces varying from the size of a sixpence to that of a half-crown will remain unbroken and untraversed by lines of fracture. Again, the mass may be wholly fractured, but on looking at the fragments edgewise a narrow, milky streak will be apparent midway between the upper and under sides of the glass, indicating that the influence of the bath has not extended through the glass. Where the process has been perfectly applied, no such phenomena are exhibited, the crystals being of uniform transparency throughout the whole mass.

Such, then, is De la Bastie's toughened glass, which possesses enormous cohesive power, and offers great resistance to the force of impact. There is, however, one peculiarity which, for the present, tells against it in a slight degree—it cannot be cut through with a diamond. Scratched its surface can be, but there the action of the diamond ceases. This drawback only applies in the case of window-glass in odd-sized frames; for the practice of the present day, with builders, is to make window-sashes of certain fixed dimensions, and glass-manufacturers work to these dimensions. It is not at all improbable, however, that ere long a means will be divised for cutting toughened glass to any size or shape; experiments are, in fact, now being conducted with this view, and so far as they have gone they give promise of success. But if toughened glass cannot be cut by the diamond, it can be readily cut and polished by the wheel, as for lustres and the like, so that wine-glasses and articles of cut glass-ware can be toughened directly they are made, and cut and polished subsequently.

Superficial observers have affected to detect in the toughening process a similar condition of matter to that which obtains in Prince Rupert's drops. The error of such a conclusion, however, becomes evident upon a little consideration. Prince Rupert's drops are made by allowing melted glass to fall into cold water; the result of which is a small pear-shaped drop, which will stand smart blows upon the thick end without injury; but the moment the thin end, or tail, is broken, the drop flies into fragments. Now, glass and water, and—as far as present knowledge goes—no other substances besides, expand while passing from the fluid into the solid condition. The theory of the Rupert drops is, that the glass being cooled suddenly, by being dropped into cold water, expansion is checked by reason of a hard skin being formed on the outer surface. This exterior coating prevents the interior atoms from expanding and arranging themselves in such a way as to give the glass a fibrous nature, as they would if the glass was allowed to cool very gradually. An examination of the Rupert's drop shows the inner substance to be fissured and divided into a number of small particles. They exist, in fact, in a state of compression, with but little mutual cohesion, and are only held together by the external skin. So long as the skin remains intact the tendency of the inner particles to expand and fill their proper space is checked and resisted by the superior compressive strain of the skin. Nor is the balance of the opposing forces disturbed by blows on the thick end of the drop, which vibrates as a whole, the vibrations not being transmitted from the exterior to the interior. But by breaking off the tail of the drop a vibratory movement is communicated along the crystalline surface, admitting of internal expansion, by which the cohesion of the particles composing the external skin is overcome, and the glass is at once reduced to fragments. As the skin of toughened

glass can be cut through with the diamond, and as, moreover, its surface can be removed by polishing and cutting with the wheel, without injury to the mass, it is evident that it must exist under conditions very dissimilar from those of a Rupert's drop. Moreover, melted glass, on being dropped into De la Bastie's bath, gives a similarly shaped body, from which the tail can be broken off, piece by piece, without injury to the body, which can be scratched, knocked and thrown about, without exhibiting any signs of deterioration. Bearing upon this point, too, comes the fact that toughened glass can be elegantly engraved, either by Tilghman's sand-blast process, or by means of hydrofluoric acid, in the ordinary way, the surface or outer skin being thus removed.

M. de la Bastie's invention marks a distinct era in the history of one of our most important industries. Never during the history of glass-manufacture, which extends over some 3,500 years, has any radical change been effected in its character. The glass-blowers of Egypt, who practised their art before the exodus of the children of Israel, and representations of whom have been found on monuments as ancient as that event, produced a similar glass to that of our own times. This has been proved by an examination of glass ornaments which have been discovered in tombs as ancient as the days of Moses. It has been proved, too, by a large bead of glass, found at Thebes, upon which was inscribed the name of a monarch who lived 1,500 years B. C., and which glass was of the same specific gravity as our own crown-glass. It is true Pliny mentions that a combination was devised in the reign of Tiberius, which produced a flexible glass; but both the inventor and apparatus were destroyed, in order, it is said, to prevent the value of copper, silver, and gold, from becoming depreciated. There is, however, no evidence whatever that this was the toughening process of De la Bastie, nor does the record in any way detract from the merits of that gentleman as the inventor of an important economic process. The fact remains that the world has now given to it for the first time, in a practical form, an invention by which the brittleness of glass is superseded by an attribute of the most valuable nature—toughness. It is by no means improbable that the old adage, "as brittle as glass," will soon be superseded by a new one —"as tough as glass."

What may be the ultimate result of the introduction of this invention in practice it is difficult to foresee, so wide-spread, so universal does its application seem. Not only is it desirable to render durable such articles as are at present made from glass, but to satisfy a want long felt in every department of art, science, and manufacture, of such a material as toughened glass; and this want can now be satisfied. So numerous are the opportunities which present for its application, and so well adapted does it appear to be where cleanliness, transparency, resistance to heat and chemical action, and comparative in-

destructibility are desiderata, that it would be idle to attempt to categorize them.

The invention is being taken up practically on the Continent, and no less in England. Messrs. Powell, of Whitefriars, are introducing it in their glass-works, and two other firms in the north of England are doing the same. It is by no means improbable that its first introduction in practice in this country will be at the aquarium now in course of erection at Westminster, where it is intended to use it for the tanks.

There still remain some questions to be answered with regard to the phenomena exhibited by toughened glass—questions, however, which in no way affect the practical value of the material. Its peculiarities continue to form the subject of investigation, and, as soon as any conclusions of value to science have been arrived at, they will be made known, so that the physical aspect of toughened glass may again be reverted to in these pages. It only remains to observe that the remarkable character and unique nature of M. de la Bastie's invention are such as to render it probable that he will not only materially benefit those of his own time, but will bequeath to posterity an invaluable legacy.—*Popular Science Review.*

FRESH-WATER MOLLUSKS.[1]

By Prof. EDWARD S. MORSE.

UNDER lily-pads and on the stems and leaves of other aquatic plants, and on stones in rivers, snails of various kinds will be found. A dipper with the bottom perforated, or made into a sieve, and attached to a wooden handle four or five feet in length, will be

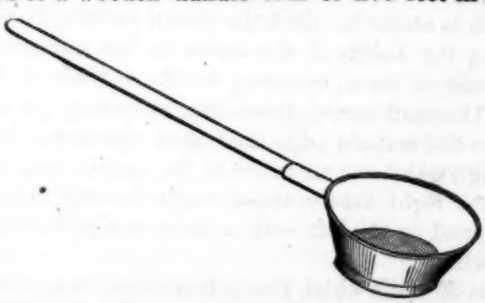


Fig. 1.—Dipper attached to a Wooden Handle for collecting Snails.

found useful in scooping up the sand or mud from the bottom of rivers and ditches. The dirt having been sifted out, the shells and other

[1] From "First Book of Zoölogy," now in press of D. Appleton & Co.

objects will be left behind. The dipper may be made as seen in Fig. 1.

Shells collected with the snails inside, and cleaned for the cabinet, are called *live shells*. They are always more fresh and perfect than dead shells. Having made the collection, the snails should be kept alive in a wide-mouthed jar, or bottle, care being taken not to have more than fifteen or twenty in a jar holding a quart of water.

Some of the following forms will have been secured:

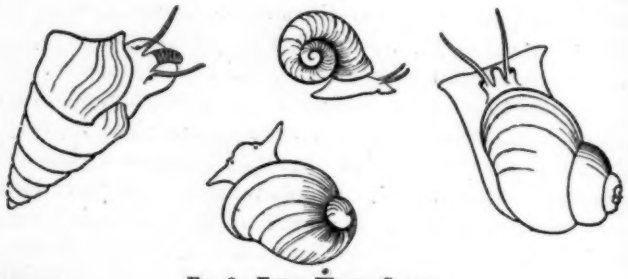


FIG. 2.—FRESH-WATER SNAILS.

The broad, creeping disk upon which the snail rests, and by which it retains its hold to the glass, is called the *foot*. The snail moves about, and crawls or glides slowly along, by means of the foot.

The two little horns or feelers, in front, are called *tentacles*, and, as the snail moves, the tentacles are seen stretched out in front, and occasionally bending, as if the creature were feeling its way along. The eyes are seen at the base of the tentacles, as two minute black dots. The mouth is between the tentacles, and below. The part from which the tentacles spring is called the *head*, and the opposite end of the body is called the *tail*. The surface upon which the snail rests is called the *ventral* or lower surface, and consequently that portion of the body which is above is called the *dorsal* surface, or back.

In watching the habits of the snails he has collected, the reader will notice some of them crawling to the surface of the water to breathe air. The snail accomplishes this by raising the outer edge of the aperture to the water's edge, and then opening a little orifice in the side, through which the air enters to the simple lung within. This orifice is on the right side in those snails having dextral or right-handed shells, and on the left side in those snails having sinistral or left-handed shells.

Many kinds of snails which live in fresh water are called air-breathers, because they are forced to come to the surface of the water to breathe air. In doing so they first expel a bubble of air, which may be seen escaping from the breathing-orifice, as in Fig. 4, *B*.

These fresh-water air-breathing snails may be kept under water for many hours before life is extinct.

Among the snails collected, there will probably be found some which have a peculiar scale on the hinder part of the body. When the snail crawls, this scale will be seen just behind the shell, as in

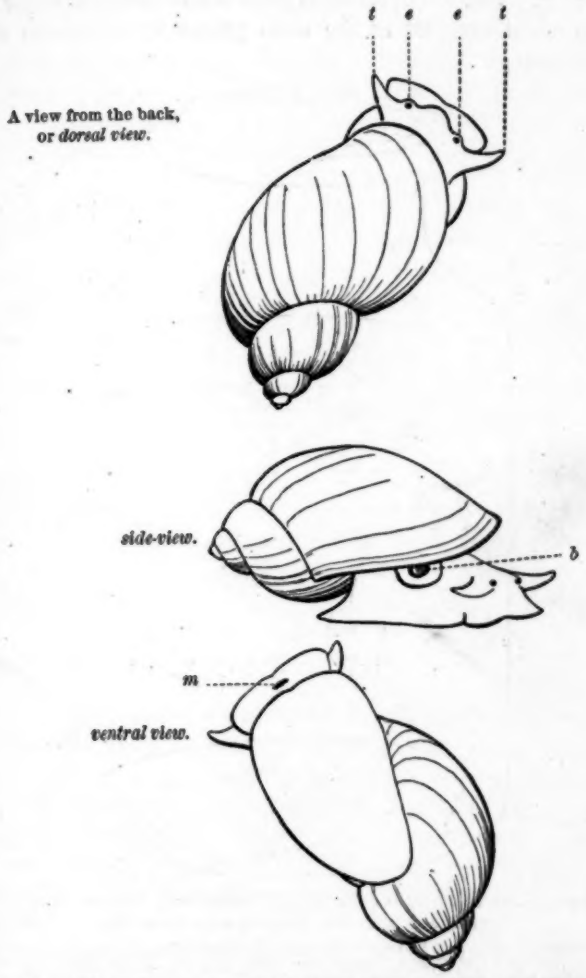


FIG. 3.—A FRESH-WATER SNAIL SEEN FROM ABOVE, FROM THE SIDE, AND FROM BELOW. *t t*, Tentacles; *e e*, Eyes; *b*, Breathing-orifice; *m*, Mouth.

Fig. 5, *o*. This scale is called the *operculum*, and when the snail has contracted, or drawn within the shell, the operculum is seen to fit the aperture of the shell, closing the shell as a stopper closes the mouth of a bottle.

Nearly all sea-snails, that is, snails which live in salt-water, and many species of fresh-water snails, and also many snails which live in damp places on the land, and which are called land-snails, have an

operculum. When the snail has retired within the shell, the operculum will look like this in the aperture of the shell (Fig. 6): A series of concentric lines will be seen marking the operculum, and these are the lines of growth, the operculum growing around the outer edge by successive additions, just as the shell grows by successive additions to its outer margin.

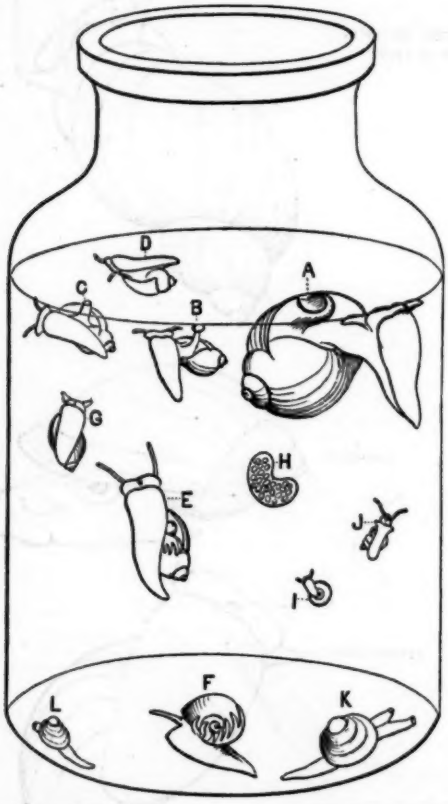


FIG. 4.—JAR OF WATER, IN WHICH IS CONTAINED A NUMBER OF SPECIES OF MOLLUSKS. SOME OF THEM ARE NEAR THE SURFACE BREATHING AIR:

A and *C* are taking in air; *B* is just expelling a bubble of air from the lung; *D* is crawling on the surface of the water; *E*, *G*, and *I*, are in the act of crawling up, to get a fresh supply of air; and *J* is a water-breather, having gills, but no lung.

The Western rivers teem with species of snails having opercula.

If the pupil has any of these operculated snails alive, he will observe that they do not come to the surface to breathe air. Instead of a lung, they have a cavity containing an organ, or part, called the gill, by means of which the snail is capable of getting from the water what the air-breathing snail gets from the air, namely, *oxygen*. It will be seen that the head of the snail is shaped differently in the snails having an operculum, the mouth being at the end of a sort of

proboscis or *rostrum*. (*See* Fig. 5.) The shells, too, are, as a general thing, more solid.

Thus far we have examined those snails which live in fresh water. Some of these were air-breathers, and came to the surface of the water

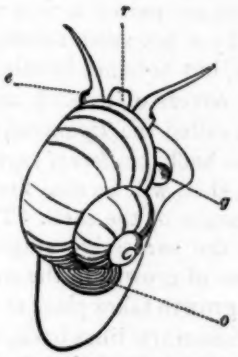


FIG. 5.—SNAIL WITH OPERCULUM.
o, Operculum; *e*, Eye; *r*, Rostrum; *g*, Entrance to Gill-Cavity.

at intervals to breathe air. We have studied other fresh-water snails which did not breathe air directly, but performed this function by means of an organ called the gill. And these snails were operculated, that is, they all possessed a little scale called the operculum, which closed the aperture tightly when the snail contracted within the shell.

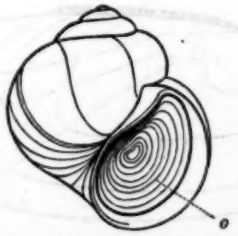


FIG. 6.—APERTURE OF SHELL CLOSED BY OPERCULUM, *o*.

We have also learned that the shells grow in size by successive additions of limy matter deposited around the free border of the aperture, and that the delicate lines which mark the surface of the shell, and which run parallel to the outer edge of the aperture, are lines of accretion, or lines of growth.

Looking over our fresh-water shells again, we find many that are known as muscles, or clams. These shells are common everywhere along the margins of brooks, rivers, and lakes. The musk-rats feed upon the soft parts of the muscles, and the remains of their feasts may be found in piles of mussel-shells all along the shores of certain lakes. The shell is composed of two pieces, or *valves*, as they are called.

The two valves are often found united, and the margin along which they are connected is called the *hinge-margin*, because the shells hinge at this part, and will open and shut as a door swings upon its hinges.

Let the pupil now examine a perfect fresh-water mussel, that is, a mussel in which the valves are united in this way, and he will observe that they are connected by a brownish substance, which is quite elastic when the shell is alive, but becomes brittle when dried. The shells are held together as the covers of a book are held together by the back. This substance is called the *ligament*, and the position of this ligament will indicate the back, or *dorsal region* of the animal.

On the outside of the shell will be seen fine lines, which run nearly parallel to the outside margin of the shell. These lines are the *lines of growth*, and indicate the successive stages of growth, or increase of the shell, as in the lines of growth in the snail-shell already studied, and, as in the snails, the growth takes place at the margin of the shells.

We may trace these concentric lines back, as they grow smaller and smaller, till they are found to start from one point at the back of the shell, and this point is called the *beak* or *umbone*. It represents the starting-point in the growth of the shell. In fresh-water mussels, the umbones are eaten away by some corrosive action of the water, and the early stages in the growth of the shell are usually destroyed. In very young shells, however, the early stages can be plainly seen.

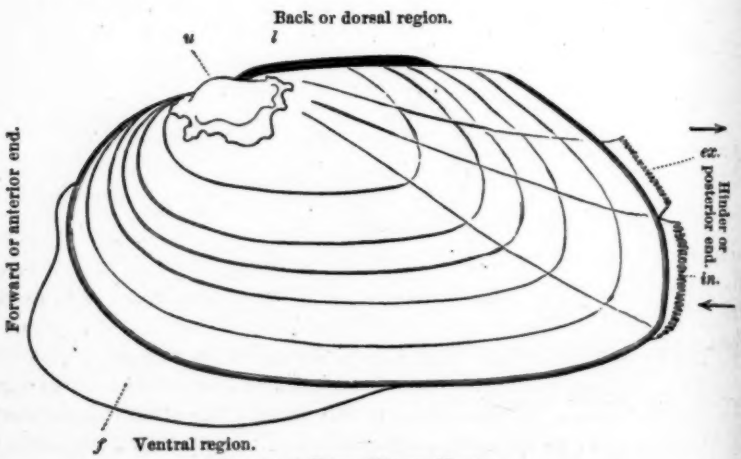


FIG. 7.—A FRESH-WATER MUSSEL.

l, Ligament; *u*, Umbone; *f*, Foot; *ex.*, Excurrent Orifice; *in.*, Incurrent Orifice.

The ligament is always behind the beak, or umbone, in fresh-water mussels, and in nearly all *bivalve* shells (so called, because they have two valves or pieces, while the snail-shells are sometimes called *univalve* shells, because they have but one valve or piece).

Now hold a perfect mussel-shell in your hand (that is, a mussel in which both valves are together, and united across the back), with the ligament uppermost, and the umbone away from the person, or beyond the ligament, and the valve on the left hand is the one which covers the left side of the animal, while the valve on the right hand covers the right side of the animal. The forward end will be the end away from the person, and the hinder end will, of course, be the end toward the person. (*See* Fig. 7.)

Let us now endeavor to collect some fresh-water mussels alive. These may be found partly buried in the sand or mud of rivers and lakes. As they crawl along partly buried in this way, they plough up the sand, leaving a well-marked furrow or groove behind them. Every boy that goes in bathing is familiar with the peculiar furrow left by the fresh-water mussel. By following such a furrow, the mussel that made it will soon be found.

Fig. 8 represents the appearance of a common fresh-water mussel in the act of crawling.

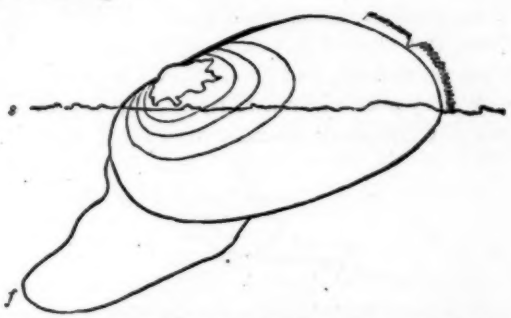


FIG. 8.—SHOWING POSITION OF MUSSEL WHEN CRAWLING.
f, Foot buried below the Surface of the Sand *s*. Above the line *s* is supposed to be water, the line representing the bottom of a lake or river.

Having collected a few in this way, they may be placed in a large, shallow pan of water, and allowed to remain quiet for a while. Gradually the shells will open a little, and from the hinder end a curious fringed border appears; on examining this border, it will soon be found that it forms two openings which lead into the shell.

Great care must be taken not to jar the dish, or the table upon which it rests. The slightest jar will cause the shells to instantly close. If some indigo, or small particles of dirt, be dropped near these openings, currents of water will be revealed; one current pouring out of the opening nearest the back, and another current as steadily pouring in at the other opening. The opening into which the current of water is passing is called the *incurrent orifice*, while the orifice from which a current of water is passing is called the *excurrent orifice*. The incurrent orifice is sometimes called the respiratory orifice, because the water is taken in to supply the gills which are the breathing or

respiratory organs of the mussel, and this orifice corresponds to the siphon in the sea-snails already studied. This current of water, besides bathing the gills, also carries in minute particles which are floating in the water, and these particles are conducted to the mouth of the creature, and swallowed as food. At the opposite end of the shell from these openings, or the forward end, a whitish, fleshy mass will be seen protruding. This is called the *foot*, and corresponds to the foot or creeping disk in the snails. By means of this foot the mussel crawls through the sand.

The mouth is above the foot, and always concealed within the shell. In Fig. 7 the foot is shown, and also the excurrent and incurrent orifices, with arrows drawn to indicate the direction of the currents of water.

In some small species of fresh-water bivalves, the excurrent and incurrent orifices are prolonged into tubes, and then they are called *siphons*. Fig. 9 represents a common species which the pupils may find in muddy brooks and ditches. By using the long-handled dipper already described, some specimens will probably be found. They are quite small, from the size of a pea to that of a nickel cent. The siphonal tubes are prominent, and the foot is long and tongue-shaped, and the animal is very active in crawling about; also in Fig. 4 *K* and *L* represent two of these small animals with bivalve shells.

FIG. 9.

The foot of these creatures resembles in appearance and action the foot of a fresh-water snail, only there is no mouth nor tentacles in sight. These parts are present, but are never protruded beyond the edges of the shell.

When the fresh-water mussels are partly open, a fleshy border will be seen just within the edges of the shell, and this is the border of the *mantle*, and corresponds to the same parts described in the snails; the fringed membrane which formed the openings at the hinder part of the mussel is simply a continuation of the mantle.

When the shells are removed from the animal, the mantle will be found lining the shells, just as the blank pages line the inside of a book-cover. While the edge of the mantle deposits the successive layers, which increase the size of the shell, the entire surface of the mantle deposits the pearly substance which lines the inner surface of the shells, and which is so characteristic of the fresh-water mussels.

Grains of sand, or other particles, getting in between the mantle and the shell, are soon covered by layers of pearly substance poured out, or secreted by the mantle. In this way pearls are formed.

If pearls are broken open, a centre, or nucleus, will be found, consisting of some particle of dirt or sand, or some substance which had found its way by accident between the mantle and the shell, and around which the pearly matter has been formed in successive layers.

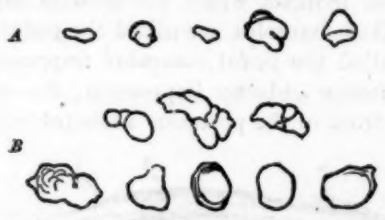


FIG. 10.—*A*, Pearly Concretions from a Fresh-water Mussel; *B*, Pearly Concretions from the Common Oyster.

In shells having a brilliant, pearly lining, or *nacre*, the pearls obtained are oftentimes very beautiful, and from certain Oriental species living in the sea, called *Avicula*, the most brilliant pearls of commerce are obtained. If, on the other hand, the nacre lining the shell is dull white, as in the common oyster, the pearls are dull colored. These kinds of pearls are often found in oysters.

The Chinese have long been familiar with the art of making artificial pearls. By partly opening the shells of certain fresh-water mussels, and inserting little lead images, or other objects, between the mantle and the shell, the objects soon become covered with a natural layer of pearl.

Let us now study the markings on the inner surface of the shells of river-mussels. The shells of these creatures are called *valves*, and are spoken of as right or left valves, according to whether they are on the right or left side of the animal.

Certain ridges and prominences will be seen at the hinge, and, when the valves are carefully joined, the ridges in one valve will correspond to grooves in the other valve. These ridges are called *teeth*. The short ones, near the beak, are called *cardinal teeth*, and the long ones *lateral teeth*. The margin upon which they occur is called the *hinge-margin*, for it is upon this margin that the valves turn. (*See* Fig. 11.)

Certain scars, or impressions, will be found marking the inside of the valves, and these indicate the point of the attachment of certain muscles to move the valves, and to enable the animal to protrude its foot, and crawl along. These marks are hence called muscular marks, or *muscular impressions*, and will be found to correspond in the right and left valves.

An irregular, round impression will be found at each end of the valve, near the hinge-margin. These show where the muscles are attached to move and close the valves, and hold them firmly together. The muscles run directly across from one valve to the other; and, to open a live mussel, it is necessary to pass a sharp blade between the

valves, and cut through the muscles, before the valves will open. These muscles are called the *adductor muscles*, and the scars or impressions on the valves are called the *adductor muscular impressions*. Very close to the adductor muscular impressions are seen smaller impressions, and these indicate where the muscles are attached which move the foot. These muscles are called the *pedal* muscles, and the impressions are called the *pedal muscular impressions*. One occurs just behind the anterior adductor impression; the other will be found just above, and in front of the posterior adductor impression.

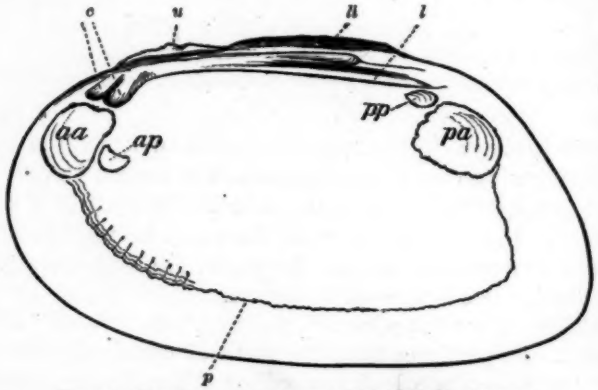


FIG. 11.—THE RIGHT VALVE OF A FRESH-WATER MUSSEL.
c, Cardinal Teeth; *l*, Lateral Tooth; *H*, Ligament; *aa*, Anterior Adductor Impression; *pa*, Posterior Adductor Impression; *ap*, Anterior Pedal Muscular Impression; *pp*, Posterior Pedal Muscular Impression; *p*, Pallial Line; *u*, Umbone.

Besides these marks, we see a delicate and slightly irregular line running from the anterior to the posterior muscular impression, just inside, and nearly parallel with the lower margin of the shell. This line is called the *pallial line*, and indicates where the mantle is attached to the shell. It will be observed that, when the soft parts are removed from the shell, the mantle adheres along this line.

When the mussel is opened by separating the adductor muscles with a knife, the valves slowly open, and after the animal is removed the valves still remain partly open, and, to preserve them closed, a string has to be tied around them, and in this condition, if the ligament is allowed to dry, the valves will then remain closed. From this it is evident that the ligament acts upon the valves to draw them apart. To keep them closed, then, the animal must continually exert itself by contracting the adductor muscles; and it will be found that, when these creatures are left in the water, undisturbed for a while, the muscles relax, and the valves partly open. The ligament is elastic, and is stretched as it were from one valve to the other, over the back. A possible imitation of the action might be represented by partly opening the lids of a book, and then gluing across the back, from one lid to the other, a sheet of elastic rubber. If, now, the lids are tightly

closed, the rubber is drawn out, or stretched across the back, and, if allowed to regain its elasticity, the lids are pulled apart. This experiment illustrates the way in which the ligament acts in those shells which have the ligament external.

THE DEEPER HARMONIES OF SCIENCE AND RELIGION.[1]

III.

PUTTING aside, then, for the present, supernaturalism and all those views of God which are distinctively Christian, we find a theology in which all men, whether they consider it or not, do actually agree—that which is concerned with God in Nature. I do not here raise the question of causes or laws; let it be allowed that Nature is merely the collective name of a number of coexistences and sequences, and that God has no meaning different from Nature. Let all this be allowed, or let the contrary of this be allowed. Such controversies may be raised about the human as well as about the Divine Being. Some may consider the human body as the habitation of a soul distinct and separable from it; others may refuse to recognize any such distinction; some may maintain that man is merely the collective name for a number of processes; some may consider the human being as possessing a free-will and as being independent of circumstances; others may regard him as the necessary result of a long series of physical influences. All these differences may be almost as important as they seem to the disputants who are occupied about them, but after all they do not affect the fact that the human being is there, and they do not prevent us from regarding him with strong feelings. The same is true of the Divine Being. Whatever may be questioned, it is certain that we are in the presence of an Infinite and Eternal Being; except through some of those exceptional perversions of the mind which I described in the last chapter, we cannot help the awe and admiration with which we contemplate him; we cannot help recognizing that our well-being depends on taking a right view of his nature.

There are two ways in which the mind apprehends any object, two sorts of knowledge which combine to make complete and satisfactory knowledge. The one may be called theoretic or scientific knowledge; the other practical, familiar, or imaginative knowledge. The greatest trial of human nature lies in the difficulty of reconciling these two kinds of knowledge, of preventing them from interfering with one another, of arranging satisfactory relations between them. In order of time the second kind of knowledge has the precedence, and avails itself of this advantage to delay and impede the arrival of

[1] From a series of papers in *Macmillan's Magazine*, on "Natural Religion."

the first kind. Before the stars, the winds, the trees and plants, could be grasped scientifically, and the laws which govern them studied, they had been grasped, and as it were appropriated, by the human mind experimentally and imaginatively. The latter kind of knowledge was in some respects better than the former. It was more intimate and realized, so that, as far as it was true, it was more available. For practical purposes, accurate scientific knowledge of a thing is seldom sufficient. To obtain complete practical command over it you must take possession of it with the imagination and feelings as well as the reason, and it will often happen that this imaginative knowledge, helped very slightly by scientific knowledge, carries a man practically further than a very perfect scientific knowledge by itself. Witness the instinctive, as we say, and unanalyzable skill sometimes possessed by savages. Moreover, this kind of knowledge is more attractive and interesting, and so has a more powerful modifying influence upon its possessor, than the other kind, for the simple reason that it takes hold of the most plastic side of his nature. But just because it is so fascinating, and is at the same time not by itself trustworthy, it has certain mischievous consequences when it comes, as it generally does, first. Then it fills the mind with prejudices, hasty misconceptions, which, seizing upon the imagination, are stereotyped in the form of superstitions; and these sometimes exercise by themselves a most pernicious influence, and in any case close the mind against the entrance of the sounder scientific knowledge. When this imaginative medley of observation and prejudice has long had possession, science arrives. Then follows a contest between the two kinds of knowledge, in which the human being suffers much. Truth cannot in the long-run be resisted, and so, after whatever defense, the fortress is carried and the phantom garrison of superstition is driven out. The mind passes now under a new set of impressions, and places itself in a new relation to the universe. Its victory over superstition has been won by placing a careful restraint upon imagination and feeling. In order not to be misled by feeling, it has been forced artificially to deaden feeling; lest the judgment should be overwhelmed by the impressiveness of the universe, it arms itself with callousness; it turns away from Nature the mobile side, and receives the shock upon the adamantine shield of the skeptical reason. In this way it substitutes one imperfect kind of knowledge for another. Before, it realized strongly, if that expression is clear, but scarcely analyzed at all; now, it analyzes most rigidly, but ceases in turn to realize. As the victory of the scientific spirit becomes more and more decided, there passes a deep shudder of discomfort through the whole world of those whose business is with realizing, and not with testing, knowledge. Religion is struck first, because the whole work of *realizing* presupposes faith, and yet, as the testing process comes late, faith is almost always more or less premature. But poetry and art suffer in their turn. How

full has recent poetry been of this complaint! One poet complains that "science withdraws the veil of enchantment from Nature;" one exclaims that "there *was* an awful rainbow *once* in heaven," but that science has destroyed it; another declares that "we murder to dissect," that we should not be always seeking, but use "a wise passiveness" in the presence of Nature; another that "Nature made undivine is now seen slavishly obeying the law of gravitation;" another buries himself in past ages "when men could still hear from God heavenly truth in earthly speech, and did not rack their brains."

And yet to complain of the march of the scientific spirit seems as idle as to complain of the law of gravitation itself. Influenced, some by a deep faith in truth, a faith, I mean, that human well-being must depend ultimately on truth; others by a fanatical truth-worship, determined to set up their idol even "amid human sacrifice and parents' tears;" others by a scientific *esprit de corps* which hates religion as belonging to a rival corporation; others by that self-importance which is gratified by inflicting pain so much more than by giving pleasure; others by the tyrant's delight in having discovered a new and exquisite torture—influenced, in short, by all the mixed motives which have ever urged on a great destructive movement, the iconoclasts pursue their course. But we may look forward to a time when this transition shall be over, and when a new reconciliation shall have taken place between the two sorts of knowledge. In that happier age true knowledge, scientific, not artificially humanized, will reign without opposition, but, the claims of science once for all allowed, the mind will also apprehend the universe imaginatively, realizing what it knows.

That kind of imaginative eclipse which is produced by the shadow of science passing over any natural object has affected in turn the phenomena of Nature, taken separately, and man and God. The "fair humanities of old religion," which found objects of love in trees and streams, and filled the celestial map with fantastic living shapes —all this has long ago disappeared. More recently man has been subjected to the analyzing process. The mechanical laws which were traced in the physical world, it was long hoped, would never suffice to explain the human being; he at least would remain always mysterious, spiritual, sacred. But nothing stops science; hesitating between curiosity that drags him on and awe that holds him back, vexed not to know, yet half ashamed of knowing, man presses on into every sanctuary. He begins now to reckon his own being among things more than half explained; nerve-force he thinks is a sort of electricity; man differs greatly, indeed, but not generically, from the brutes. All this has for the time at least the effect of desecrating human nature. To the imagination human nature becomes a thing blurred and spoiled, not really because the new view of it is in itself degrading, but because the imagination had realized it otherwise, and cannot in any

short time either part with the old realizing or perfect a new one. Lastly, Science turns her smoked eye-glass upon God, deliberately diminishing the glory of what she looks at that she may distinguish better. Here, too, she sees mechanism where will, purpose, and love, had been supposed before; she drops the name God, and takes up the less awful name of Nature instead.

It is in this last case that the desecration produced by science is most painfully felt. This is partly, of course, because the sacredness violated was greatest here; but there is also another reason. Science cannot easily destroy our feeling for human beings. We are in such close contact with our own kind, our imagination and affections take such fast hold of our fellow-men, as to defy physiology. If it were otherwise we should want a word—*Ananthropism*—to answer to atheism. Even as it is the thing is occasionally to be seen. Among medical students there are not a few ananthropists, that is, men in whom human affections have not been strong enough to resist the effect of science in lowering the conception of humanity. But in general the imagination triumphs in this case over the reason. In the case of the physical world it is otherwise. This, for the majority of men, is, I fancy, almost completely desecrated, so that sympathy, communion with the forms of Nature, is pretty well confined to poets, and is generally supposed to be an amiable madness in them. But then this was not done by science, it had been done before by monkish Christianity. Chaucer complains, hundreds of years before the advent of physical science, of the divorce that had been made between the imagination and physical nature—"But now may no man see none elves mo." It was owing, according to him, to the preachings and bannings of "limitours and other holy frères." Nature had been made not merely a dead thing, but a disgusting and hideous thing, by superstitions of imps, witches, and demons; so much so that Goethe celebrates science as having restored Nature to the imagination and driven away the Walpurgisnacht of the middle ages; and, indeed, by turning attention upon the natural world, by bringing a large number of people to take careful notice of its beauties, science may have given back to the imagination, in this department, as much as it has taken away.

But the conception of God is so vast and elevated that it always slips easily out of the human mind. The task of realizing what is too great to be realized, of reaching with the imagination and growing with the affections to a reality almost too great for the one, and almost too awful for the other, is in itself exceptionally difficult. To do this, and yet at the same time carefully to restrain the imaginations and affections as science prescribes, is almost impossible; yet those who perpetually study Nature, unless they specialize themselves too much, will always in some sense feel the presence of God. The unity of what they study will sometimes come home to them and give a sense of

awe and delight, if not of love. But upon those who do not study Nature the advance of science can have no other effect than to root out of their minds the very conception of God. The negative effect is not counterbalanced by any positive one. With them, if the supernatural person whose will holds the universe together is denied, the effect is that the universe falls at once to pieces. No other unity takes his place, and out of the human mind there perishes the most elevating thought, and out of human life the chief and principal sacredness. The remedy for this is to be found in the study of Nature becoming universal. Let all be made acquainted with natural laws; let all form the habit of contemplating them, and atheism in its full sense will become a thing impossible, when no mind shall be altogether without the sense, at once inspiring and sobering, of an eternal order.

But these remarks on the difficulty of harmonizing the scientific with the imaginative knowledge of things, are by way of digression. Our business at present is with the fact that knowledge is of these two kinds, and that the complete or satisfactory knowledge of any thing comes from combining them. When the object of knowledge is God, the first kind of knowledge is called theology, and the second may be called religion. By theology the nature of God is ascertained and false views of it eradicated from the understanding; by religion the truths thus obtained are turned over in the mind and assimilated by the imagination and the feelings.

When we hear it said, as it is said so commonly now, that the knowledge of God is impossible to man, and therefore that theology is no true science, of course the word God is used in that peculiar sense of which I have spoken above. Nature every one admits that we know or may know; but of any occult cause of phenomena, or of any supernatural being suspending the course of natural laws, it is denied that we can know any thing. But since every sort of theology agrees that the laws of Nature are the laws of God, it is evident that in knowing Nature we do precisely to the same extent know God. I am proposing for the present to treat the words of God and Nature as absolutely synonymous, which up to a certain point every one allows them to be. So long as we do so we are in no danger of trespassing beyond the proper domain of human inquiry; so long as we do so, theology, instead of being additional or antagonistic to science, is merely another name for science itself. Regarded in this way, we may say of God, that so far from being beyond knowledge, he is the one object of knowledge, and that every thing we can know, every proposition we can frame, relates to him. It may seem, however, that little is to be gained from giving this unusual sense to the word theology. If in the ordinary sense it is the name of an imaginary and delusive science, taken in this sense as a synonym for science itself, it is purely useless. By giving the word such an extension, it will be said, you destroy all its force. That we ought to study theology be-

comes a truism if it means merely that all knowledge is valuable; the old maxim, that in the knowledge of God is life, loses all its grandeur if it is interpreted to mean merely that the more things you know the more dangers you will be in a condition to avoid. Can we not, then, give more precision, more definiteness, to the notion of the knowledge of God?

The notion is to be limited in two ways, one of which has been partially indicated already. The scientific school themselves save us the trouble of explaining the first of these limitations; it is they who, in this age, have made clear to every one the difference between the study of the universe and mere universal study. When they tell us in the very language of theology that all hope and all happiness lies in the knowledge of Nature, that this is a treasure to be valued above rubies and precious stones, how do they limit the word Nature? They mean it certainly to include the whole universe. What is it, then, that they exclude? One would fancy at first sight that they are merely praising knowledge in general, and that they are not particular about kinds of knowledge. Yet we know that they are remarkably exclusive in their notions of knowledge, and that they are as vehement in condemning some sorts as in recommending others. What is there, then, that can possibly be studied besides the universe?

There is something which sets itself up as a just reflection of the universe, and which it is possible to study as if it were the universe itself; that is, the multitude of traditional unscientific opinions about the universe. These opinions are, in one sense, part of the universe; to study them from the historic point of view is to study the universe; but when they are assumed as an accurate reflection of it so as to divert attention from the original, as they are by all the votaries of authority or tradition, then they may be regarded as a spurious universe outside and apart from the real one, and such students of opinion may be said to study and yet not to study the universe.

This spurious universe is almost as great as the genuine one. There are many profoundly learned men whose whole learning relates to it, and has no concern whatever with reality. The simplest peasant who, from living much in the open air, has found for himself, unconsciously, some rules to guide him in divining the weather, knows something about the real universe; but an indefatigable student, who has stored a prodigious memory with what the schoolmen have thought, what the philosophers have thought, what the Fathers have thought, may yet have no real knowledge; he may have been busy only with the reflected universe. Not that the thoughts of dead thinkers stored up in books are not part of the universe as well as wind and rain; not that they may not repay study quite as well; they are deposits of the human mind, and by studying them much may be discovered about the human mind, the ways of its operation, the stages of its development.

Nor yet that the thoughts of the dead may not be of the greatest help to one who is studying the universe; he may get from them suggestions, theories which he may put to the test, and thus convert, in some cases, into real knowledge. But there is a third way in which he may treat them which makes books the very antithesis to reality, and the knowledge of books the knowledge of a spurious universe. This is when he contents himself with storing their contents in his mind, and does not attempt to put them to any test, whether from superstitious reverence or from an excessive pleasure in mere language. He may show wonderful ability in thus assimilating books, wonderful retentiveness, wonderful accuracy, wonderful acuteness; nay, if he clearly understands that he is only dealing with opinions, he may do good service in that department, for opinions need collecting and classifying as much as botanical specimens. But one often sees such collectors mistaking opinions for truths, and depending for their views of the universe entirely upon these opinions, which they accept implicitly without testing them. Such men may be said to study, but not to study the universe.

There are other classes of men of whom much the same may be said. The scientific school, when they recommend the study of Nature, do not mean, for example, the mere collecting of facts, however authentic. Nature with them is not a heap of phenomena, but laws discerned in phenomena, and by a knowledge of Nature they mean a just conception of laws much more than an ample store of information about phenomena. Again, in an age like the present, when methods of inquiry have been laid down and tested by large experience, they do not dignify with the name of the study of Nature any investigation, however earnest or fresh, of the facts of the world, which does not conform to these methods, or show reason for not doing so.

Knowledge of Nature understood in this sense, and obtained in this way, is what we are now told is alone valuable—what human happiness depends on. And assuredly it deserves to be called in the strictest sense theology. If God be the Ruler of the world, as the orthodox theology teaches, the laws of Nature are the laws by which he rules it. If you prefer the pantheistic view, they are the very manifestations of the Divine Nature. In any case the knowledge of Nature, if only it be properly sifted from the corrupting mixture of mere opinion, is the knowledge of God. That there may be another and deeper knowledge of God beyond it does not affect this fact.

But is theology a mere synonym for science? If so, the scientific man may fairly say: "I need not concern myself with it; I have already a name for my pursuit which satisfies me; it does not interest me to hear that there is another name which also is appropriate." Is there no special department of science which may be called theological, to distinguish it from the other departments? It is this which so many scientific men now deny. They say there is certainly such a special

department, but it is not a department of science, for it lies outside the domain of science. It is concerned with causes, whereas science knows nothing of causes; it is concerned with supernatural phenomena which science puts aside as either impossible or unverified. All that this objection means is, that many theologies have been supernaturalistic, and have been occupied with causes, and that though as a matter of course they have not been *exclusively* supernaturalistic and occupied with causes, yet they have been so sufficiently to justify us in appropriating the word theology to systems that have these characteristics. To say, then, that theology is a spurious science, is to say that in most theological systems there is an element more or less predominant which is unscientific. But, even if it were convenient to give to this element the name of theology, it would not follow because theology in this sense may be a spurious science—and etymologically theology is the science of God—that therefore the science of God is a spurious one. You may use the word theology in its etymological sense, or you may give it a more special technical sense to suit convenience; but you must not confound the two senses of the word together. As I have said, all science belongs properly to the science of God, and might legitimately be called theology. I believe also that there is a special department of knowledge which, without necessarily concerning itself with the supernatural, or with final causes, might both legitimately and conveniently be called theology.

Considered in its practical bearings upon human life, the study of Nature resolves itself into the study of two things, a force within the human being, and a necessity without him. Life, in short, is a mechanical problem, in which a power is required to be so advantageously applied as to overcome a weight which is greater than itself. The power is the human will, the weight is Nature, the motive of the struggle between them is certain ideals which man instinctively puts before himself—an ideal of happiness, or an ideal of perfection. By means of science he is enabled to apply the power in the most advantageous manner. Every piece of knowledge he acquires helps him in his undertaking. Every special science which he perfects removes a new set of obstacles, procures him a new set of resources. And in his conflict with natural difficulties his energy and hope are in proportion to his power of knowing and measuring the force he has, and the resistance he will meet with. When he is able to measure this precisely, his hope becomes confidence even in circumstances which might seem the most alarming. We allow ourselves to be hurried through the air at the rate of fifty miles an hour, with a noise and impetus appalling to a by-stander, and all the while read or sleep comfortably. Why? Because the forces we have set in motion are all accurately measured, the obstacles to be met fully known. When the measurement is only approximate, there is not confidence, but only hope predominating over fear. The experienced sailor feels

this; he trusts himself to the open sea, because he knows that he is pretty well matched against the necessity he provokes, though he cannot know that he is the superior because he can calculate a good many of the dangers, though not all.

This is the case in each of the separate undertakings that make up life. To each of them belongs its appropriate knowledge, upon which our equanimity and repose of mind, as far as the particular undertaking is concerned, depend. But life itsef, taken as a whole, is an undertaking. Life itself has its objects which make it interesting to us, which lead us to bear the burden of it. These objects, like those minor ones, are only to be attained by a struggle between the power Will and the weight Nature, and in this struggle also both energy and success depend upon a certain knowledge which may enable us to apply the power with advantage. But the knowledge required in this case is of a more general kind; it is not a knowledge confined to certain sets of phenomena, and giving us a power correspondingly limited, but it is a general knowledge of the relation in which human life stands to the universe, and of the means by which life may be brought into the most satisfactory adaptation to it. Now, by what name shall we call this knowledge?

Every one has his general views of human life, which are more or less distinct. Upon these general views more than upon any thing else connected with the understanding depends the character of every one's life. Morality is theoretically independent of all such views, but practically and in the long-run it varies with them. What has life to give? How far does it lend itself to our ideals? These are practically questions quite as important to morality as those which lie within the province of morality itself—as the questions, what are or what ought to be our ideals? They are also quite as important to human happiness as all particular measures contrived to increase human happiness. No man fights with any heart if he thinks he has Nature against him. If a man believes that men are not made to be happy, he will lose the energy to do even what can be done for their happiness; he will give up the pursuit of virtue if he meets with more than a certain degree of discouragement in it.

Of an unfavorable view of human life there are three principal consequences—crime, languor, and suicide. The majority of crimes, and still more of meannesses, it seems to me, are not committed from bad intentions, but from a despair of human life. "I am sorry, but I *must* do it; I am driven to it; everybody has to do it; we must look at things as they are;" these are the reflections which lead men into breaches of morality. "*Sic vivitur*," says Cicero, selling Tullia. The feeling that life will not allow people to do always what is right, faint perhaps in each individual mind, grows strong when many who share it come together: it grows stronger by being uttered, stronger still by being acted upon; it creates an atmosphere of laxity; morality

retires more and more out of view; until the thought of crime itself, and even of enormous crime, becomes familiar, and at last is carried almost unconsciously into act. It is not, then, from want of morality that men do wrong, but from want of another sort of knowledge. They know what is right and what is wrong; it is not from overlooking this distinction that they fall into the wrong, nor would they escape the danger by reflecting upon it ever so much. What determines their action is a belief in some sort of necessity, some fatality with which it is vain to struggle; it is a general view of human life as unfavorable to ideals.

Another such general view of human life produces apathy. A man who has persuaded himself that we are the creatures of circumstances, or that we are the victims of laws with which it is impossible for us to cope, will give up the battle with Nature and do nothing. Perhaps he has his head full of instances of the best endeavors after happiness failing entirely, or by some fatality producing extreme unhappiness; of the purest and noblest labors producing mischief which complete inactivity would have avoided; how Queen Isabella introduced the Inquisition; how Las Casas initiated the slave-trade; how pauperism has been over and over again fostered by philanthropy; how the Prince of Peace himself, according to his own saying, brought a sword upon the earth. He may think that human life, as it runs on naturally, is not a bad thing, but that all attempts to control it or improve it are hopeless; that all high ideals are merely ambitious; that purpose and, still more, system and all sophistication of life are mischievous. And so he may come to renounce all free-will, he may resign himself to the current of ordinary affairs, and become a mere conventionalist, reconciling himself to whatever he does not like, and gradually induced to tolerate with complete indifference the most enormous evils. Against such a perversion of mind morality is no defense; what is needed is not a new view of what ought to be—such a man knows well enough what ought to be—but a new view of what can or may be, a more encouraging view of the universe.

Sometimes the despair of human life goes to a much greater length. Human life is a game at which we are not forced to play; we may at any time throw up the cards. That only a few do so proves that more or less distinctly most of us have a general view of life not altogether unfavorable. We are for the most part hardly aware of this general view, because it is always the same. We should become painfully aware of it if it were suddenly to change. There is, as it were, a suicide-mark below which our philosophy is always liable to sink. If we came to think life irreconcilably opposed to our ideals, and at the same time were enthusiastically devoted to our ideals, life would become intolerable to us. If our sense of the misery or emptiness of life became for some reason much more keen than it is, life would at last become intolerable to us. With individuals one of these two things is constantly taking place; they might just as well take place with

whole societies or nations. Something of the kind happened with the Stoics of the imperial period. Their philosophy was only just above suicide-mark, and was continually dropping below it. In Asia the same is true of whole populations, with whom the value of life has sunk to the very lowest point.

Of all these classes of men we say very justly that they want faith. Their criminality or languor or despair are the consequences of their having no faith. But we sometimes express the same thing differently and say that they have no God, no theology. With our Christian habit of connecting God with goodness and love, we confuse together the notions of a theology and a faith. Let us reflect that it is quite possible to have a theology without having a faith. We may believe in a God, but a God unfavorable, hostile, or indifferent to us. In the same way we may believe in a God neither altogether friendly nor altogether the reverse. The different pagan theologies were of this kind, and even many Christian sects, while nominally holding the perfect benevolence of God, have practically worshiped a Being who in this respect did not differ from the pagan deities.

It would be legitimate to call such general views of the relation of Nature to our ideals by the name of theology in all cases, and not merely those particular general views which are encouraging. If we believe that Nature helps us in our strivings, we have both a theology and a faith; if we believe that Nature is indifferent to us, or hostile to us, we have no faith, but we have still a theology. We have still a definite notion of God's dealings with us. And this use of the word is not only justified by its etymology; it is much more conformable to actual usage. To identify theology with the doctrine of the supernatural is, as I have pointed out, to narrow the meaning of the word unnaturally, and to appropriate it to a particular part of a particular theological system. The practical effect of giving this technical sense to a word which in the common understanding has a much larger meaning, is to produce a deception. When those who reject the supernatural declare theology to be exploded, they are commonly understood to mean that a vast mass of doctrine, partly moral, partly historical, partly physical, in which the supernatural is mixed up, is exploded, whereas all they really say is that just that part is exploded which is supported only by the evidence of the supernatural. In like manner it is but a small part of what is commonly understood by theology that has to do with final causes, and yet those who consider final causes not objects of knowledge are fond of drawing the inference that all theological systems must be systems of spurious knowledge. Sometimes this juggle which is practised with the word theology becomes grotesquely apparent, and a skeptic will tell us in the same breath that theology deals with matters entirely beyond the range of human intellect, and that theology has been refuted by the discoveries of modern science.

The questions which we all understand to be theological are such as these: Is there a reward for virtue? Is there a compensation for undeserved misery? Is there a sure retribution for crime? Is there hope that the vicious man may become virtuous? Are there means by which the pressure upon the conscience produced by wrong-doing may be removed? Are there means by which the mind disposed to virtue may defend itself from temptation? In one word, is life worth having, and the universe a habitable place for one in whom the sense of duty has been awakened? These questions are answered in different ways by different men. But they are answered in some way by all men, even by those who consider themselves to have no theology at all. Christianity is the system which answers them in the most encouraging way. It says that virtue in the long-run will be happy partly in this life, but much more in a life beyond the grave. It says that misery is partly the punishment of crime, partly the probation of virtue; but in the inexhaustible future which belongs to each individual man there are equivalents and over-payments for all that part of it which is undeserved. It says that virtue, when tried, may count upon help, secret refreshings that come in answer to prayer—friends providentially sent, perhaps guardian angels. It says that souls entangled in wrong-doing may raise themselves out of it by a mystic union with Christ, and burdened consciences be lightened by sharing in the infinite merit of his self-sacrifice. If you ask on what so happy and inspiring a belief rests, the evidence produced is in part supernatural.

This is not only a theology but a faith, the most glorious of all faiths. But those who do not heartily share it, or who consciously reject it, yet give some answer to these questions. They have a theology as much as Christians; they must even have a faith of some sort, otherwise they would renounce human life. It may be stated, perhaps, much as follows:

"We have not much reason to believe in any future state. We are content to look at human life as it lies visibly before us. Surveying it so, we find that it is indeed very different from what we could wish it to be. It is full of failures and miseries. Multitudes die without knowing any thing that can be called happiness, while almost all know too well what is meant by misery. The pains that men endure are frightfully intense, their enjoyments for the most part moderate. They are seldom aware of happiness while it is present, so very delicate a thing is it. When it is past they recognize it, or perhaps fancy it. If we could measure all the happiness there is in the world, we should perhaps be rather pained than gladdened by discovering the amount of it; if we could measure all the misery we should be appalled beyond description. When from happiness we pass to the moral ideal, again we find the world disappointing. It is not a sacred place any more than it is a happy place. Vice and crime very frequently prosper in it. Some of the worst of men are objects of enthu-

siastic admiration and emulation. Some of the best have been hated and persecuted. Much virtue passes away entirely unacknowledged; much flagrant hypocrisy succeeds in its object.

"Still on the whole we find life worth having. The misery of it we find ourselves able to forget, or callously live through. Fortunately we have not imaginations strong enough to realize the sum of it, and we contrive to turn our thoughts away from the subject. And though the happiness is not great, the variety and novelty are. Life is interesting, if not happy. In spite of all the injustice which shocks us in human destiny, the inequality with which fortune is meted out, yet it may be discerned that, at least in the more fortunate societies, justice is the rule and injustice the exception. There are laws by which definite crimes are punished, there is a force of opinion which reaches vaguer offenses, and visits even dispositions to vice with a certain penalty. Virtue is seldom without some reward, however inadequate; if it is not recognized generally or publicly, it finds here and there an admirer, it surrounds itself with a little circle of love; when even this is wanting it often shows a strange power of rewarding itself. On the whole, we are sustained and reconciled to life by a certain feeling of hope, by a belief, resting on real evidence, that things improve and better themselves around us."

This is certainly a very different faith from Christianity. Whether it deserves to be called a faith at all, whether it justifies men in living and in calling others into life, may be doubted. But it is just as much a theology as Christianity. It deals with just the same questions and gives an answer to them, though a different answer. Both views, whatever may be professed, are views about God. Christianity regards God as a friend; it says that he is Love. The other view regards him as awful, distant, inhuman, yet not radically hostile.

It is said that such vague, general views do not deserve to be called science. This is of course admitted. There exists at the present moment no scientific theology independent of the supernatural and of the search for final causes. But this is not because no such theology can be constructed, but merely because it has not yet been constructed. Evidently it is constructing itself fast. The more men come to know Nature and to feel confidence in their knowledge, the more eagerly they will consider what is the attitude of Nature toward human beings. This question is not one which is in any way removed from human knowledge, it is not one which it can be considered morbid to betray curiosity about. Yet this is *the* question of theology. Not only is it the only question with which theology ought to be concerned; it is the only question with which theology ever has been concerned. The theologies of the world are merely different attempts to answer it. If they have for the most part trespassed upon the domain of the supernatural, this has not been because theology is necessarily concerned with the supernatural, but in some cases because the line

between the natural and supernatural had not been clearly drawn, in some cases because it was honestly believed that supernatural occurrences had happened and could be substantiated by sufficient evidence, and that such occurrences were calculated to throw new light upon the relation of God to man. If this belief was a delusion, theology must fall back upon the evidence of Nature. She may have to alter her idea of God, she may have to regard him with fear and cold awe as in the days before the Gospel was published; she may cease to be a faith, and may become instead an oppression—a scientific superstition. But theology will remain notwithstanding a perfectly legitimate science, one which, whether under that name or under another, men will always study with an interest they can feel in no other, one which stands in a more intimate relation than any other to morality, and must always be taught in conjunction with morality.

We lay it down, then, that the subject of theology is the relation assumed by the universe toward human ideals, and, as we propose here to waive the question of the supernatural and to treat the universe as consisting solely of the order of Nature, this will be the same thing for our present purpose as the relation assumed by Nature toward human ideals. But here we must beware of a common misconception. It is often said that when you substitute Nature for God you take a thing heartless and pitiless instead of love and goodness. Undoubtedly the God in whom Christians believe has much more of love and goodness than can be discovered in Nature. But when it is said that there are no such qualities in Nature, that Nature consists of relentless and ruthless laws, that Nature knows nothing of forgiveness, and inexorably exacts the utmost penalty for every transgression, a confusion is made between two different meanings which may be given to the word Nature. We are concerned here with Nature as opposed to that which is above Nature, not with Nature as opposed to man. We use it as a name comprehending all the uniform laws of the universe as known in our experience, and excluding such laws as are inferred from experiences so exceptional and isolated as to be difficult of verification. In this sense Nature is not heartless or unrelenting; to say so would be equivalent to saying that pity and forgiveness are in all cases supernatural. It may be true that the law of gravitation is quite pitiless, that it will destroy the most innocent and amiable person with as little hesitation as the wrong-doer. But there are other laws which are not pitiless. There are laws under which human beings form themselves into communities, and set up law courts in which the claims of individuals are weighed with the nicest skill. There are laws under which churches and philanthropical societies are formed, by which misery is sought out and relieved, and every evil that can be discovered in the world is redressed. Nature in the sense in which we are now using the word, includes human nature, and therefore, so far from being pitiless, includes all the pity that belongs to the whole

human family, and all the pity that they have accumulated, and, as it were, capitalized in institutions, political, social, and ecclesiastical, through countless generations.

People are misled by the fact that Nature is often used in another sense, and opposed, not to the supernatural, but to man. Nature is, for shortness, often put instead of inanimate Nature. Inanimate Nature is of course pitiless. It consists of laws which, like the law of gravitation, take no note of happiness or misery, virtue or vice. But if we abandoned our belief in the supernatural, it would not be only Nature in this restricted sense that would be left to us; we should not give ourselves over, as it is often rhetorically described, to the mercy of merciless powers—winds and waves, earthquakes, volcanoes, and fire. The God we should believe in would not be a passionless, utterly inhuman power. He would indeed be a God, often neglecting us in our need, a God often deaf to prayers. Nature including humanity would be our God. We should read his character not merely in the earthquake and fire, but also in the still small voice; not merely in the destroying powers of the world, but, as Mohammed said, in the compassion that we feel for one another; not merely in the storm that threatens the sailor with death, but in the life-boat and the Grace Darling that put out from shore to the rescue; not merely in the intricate laws that confound our prudence, but in the science that penetrates them and the art which makes them subservient to our purposes; not merely in the social evils that fill our towns with misery and cover our frontiers with war, but in the St. Francis that makes himself the brother of the miserable, and in the Fox and Penn that proclaim principles of peace.

Let us take one of the principal maxims of the supernatural theology, and observe how it is modified by the rejection of the supernatural. That the just man will assuredly be rewarded with happiness is a maxim resting upon evidence involving the supernatural. It depends upon belief in a God of much more goodness and justice than we can find in Nature; it assumes a future state of which science furnishes no clear evidence. Even when the Psalmist, speaking merely of the present life, wrote, "I have been young, and now am old, and yet saw I never the righteous forsaken, nor his seed begging their bread," he perhaps thought of supernatural interpositions by which evil was averted from the just man. Suppose, now, that we repudiate all such beliefs, and confine ourselves strictly to the facts of Nature as we discover them from uniform experience. Let us suppose that the ordinary laws of Nature govern the lot of the just man, and that no exemptions are made in his favor. Do we find that these ordinary laws take no account of his justice, and that his prospects are in no respect different from those of the unjust man? Is Nature, as distinguished from the supernatural, regardless of the distinction between virtue and vice? No doubt Nature is not a perfectly just judge. The just

man has misfortunes like the unjust; he may suffer from accident or disease. His justice may be denied; he may suffer the penalties of injustice. All this may happen in particular cases, and yet no one doubts that on the whole the just man reaps a reward for his justice. A very simple law operates to reward him. By his justice he benefits the community, and the community, partly out of gratitude, partly out of an interested calculation, repay him for the service he has done. This law fails of its effect in a good number of cases, but in the majority of cases it does not fail. And when it fails, it seldom fails altogether. There is generally some reward for justice, if not always an adequate reward. Accordingly, not only Christians, or those who believe in something more than Nature, but those whose only God is Nature, and even those whose knowledge of Nature is very superficial, fully recognize that virtue is rewarded. "Honesty is the best policy" has become a proverb, and hypocrites have come into existence hoping to secure the reward without deserving it. We see, then, that those who believe in Nature only may be said to believe not only in a God, but, in some sense, in a personal God. Their God, at least, has so much of personality that he takes account of the distinction of virtue and vice, that he punishes crime, and that he relieves distress.—*Macmillan's Magazine.*

THE GREAT IOWA METEOR.

By Dr. GUSTAVUS HINRICHS.

ON the evening of Friday, February 12, 1875, at twenty minutes past ten o'clock, one of the most brilliant meteors, of modern times illuminated the entire State of Iowa, and adjacent parts of the States of Missouri, Illinois, Wisconsin, and Minnesota. The southeastern portion of Iowa was bright as day, while the great meteor, in descending to the earth, passed from Appanoose County to Iowa County. The meteor, in rapidly moving through the atmosphere, produced a great variety of sounds—rolling, rumbling, and detonations of fearful intensity—which in a large portion of Iowa County shook the houses as if moved by an earthquake.

But three days after the great phenomenon, a meteoric stone, weighing seven pounds, was found by Miss Sarah Sherlock, while on her way from school—precisely where observers had seen a "glowing coal" descend to the earth. In April and May, while the farmers were cultivating the land, about 400 pounds of meteoric stones were gathered on the meteorite-field of Iowa County. Quite recently two large meteorites have been found, aggregating 120 pounds. But these 500 pounds of meteoric stones apparently are only a portion of a smaller fragment of the entire meteoric body, so that the whole mass

falling to the earth, as the great Iowa meteor of February 12, 1875, must have weighed about 5,000 pounds.

Even what has been gathered thus far permits us to rank this meteor among the best observed and richest in meteorites on record. Such are the meteors of Pultusk, Poland (January 30, 1868); Knyahinya, Hungary (June 9, 1866); Orgueil, France (May 14, 1864); Guernsey County, Ohio (May 1, 1860); Parnallee, India (February 28, 1857); and L'Aigle, France (April 26, 1803).

Thinking that so remarkable a meteor and so rich a shower of meteorites deserve the attention of the readers of THE POPULAR SCIENCE MONTHLY, we offer a short description of them, and shall close with a few suggestions in regard to the origin of these bodies, and their place in the grand history of cosmos.

I. THE GREAT IOWA METEOR.[1]—The great Iowa meteor consisted of an elongated, pear-shaped mass of the most dazzling whiteness. The bulk of this mass was about 2,000 feet long and 400 feet in diameter; the narrow white trail was about 4,000 feet long and 40 feet in diameter. This body was posteriorly enveloped by a much less brilliant trail, shading from orange inside to greenish outside, and extending about nine miles along the described path of the meteor. Persons in the track of the meteor saw a brilliant circular disk of white light, surrounded by an orange to greenish halo, the dim light of which was constantly traversed by narrow bands of brilliant white, running from the central disk in irregularly-curved lines toward the circumference. As this body, increasing in brilliancy and apparent magnitude, was rapidly approaching, both men and animals were overcome with fear.

The meteor, when by striking the atmosphere of the earth it became visible, was at an altitude of 150 miles vertically above the little village of Pleasantville, about midway between Kirksville and Milan, in Northern Missouri. Descending at an angle of about 45° toward the earth's surface, it moved a little east of north, gradually deviating more and more toward the east, so as to describe a curve,[2] the concavity of which is turned eastward. This track of the meteor passed a couple of miles east of Centreville and Moravia in Appanoose County, Iowa; almost directly over Eddyville on the Des Moines River; crossed almost diagonally the northeastern (Prairie) township of Keokuk County; passed one and a half mile east of Marengo in Iowa County, and finally exploded over a point three miles southwest of the little station of Norway on the Chicago & Northwestern Railway, over the boundary-line of Benton and Iowa Counties, at an altitude of about ten miles.

[1] The facts in regard to the meteor we have collected from the very full and reliable "Account of the Detonating Meteor of February 12, 1875. By C. W. Irish, C. E., Iowa City, Iowa, *Daily Press* Job-Printing Office, 1875."

[2] The total length of the orbit is 210 miles; the time during which the meteor described this orbit was about ten seconds: hence the velocity was about 21 miles a second.

While the meteor crossed the northwestern (Prairie) township of Keokuk County, it was seen to divide into two unequal parts, a small eastern portion continuing its motion northeastward, but soon losing its brilliancy, and a seven to fourteen times greater western portion which remained intensely brilliant until its final explosion. *It was the smaller portion of the meteor which produced the meteorite shower in Iowa and Amana Townships of Iowa County;* hence it is highly probable that several thousand pounds of meteorite, some in pieces of over a hundred pounds, will yet be found east and north of the final explosion of the main portion of the meteor, that is, in Florence Township of Benton County, in Fairfax Township of Linn County, and in Lenox Township of Iowa County. In fact, observers have seen "large glowing coals," as they call them, fall in this region where Linn, Benton, and Iowa Counties meet.

While dividing, the meteor produced two tremendous detonations, and, after the main body had crossed the railroad at Marengo, it produced three terrific detonations, which shook the buildings for miles around, so as to create in the residents the fear of an earthquake.

Besides these detonations, the meteor was accompanied with a variety of other sounds, heard over a circular area of 150 miles in diameter. To those farthest away from the orbit it sounded as if their chimney was on fire, and an astonishingly large number of persons missed the sight of the meteor because they hurried to their stoves and flues to check the apparent fire. Those nearer the track heard a prolonged rumbling and rolling sound, which they compare to that produced by the running of a train over a high and long trestle-bridge. Others, still nearer the region of final explosion, hurried up-stairs, thinking that the plastering had fallen on the heads of their children sleeping in the upper story. Many in this same region heard the clank and clatter of heavy, hard bodies striking against each other, or against the hard ground.

II. The Iowa County Meteorites.—The meteorites thus far found occur in an elliptical area stretching from Amana vor der Höhe, in Amana Township, to Boltonville, in Iowa Township, a distance of eight miles. The minor axis of this ellipse measures about three miles. The entire meteorite-field of Iowa County thus far covers, therefore, an area of eighteen square miles. In the northwest the largest pieces are found; toward the southeast, the meteorites become gradually smaller. This agrees with their derivation from the minor portion of the meteor. As the entire drift was eastward, the resistance of the air would, to some extent, produce precisely this distribution of the meteorites according to size.

The principal village near the meteorite region is Homestead,[1] a

[1] I gratefully acknowledge many personal obligations to residents of this place, especially to Messrs. William Moerschel, Frederick Moerschel, Geisler, Fehr, Dickel, Noë, and others.

station on the Chicago, Rock Island & Pacific Railroad, about twenty miles west of Iowa City. This little station became the headquarters

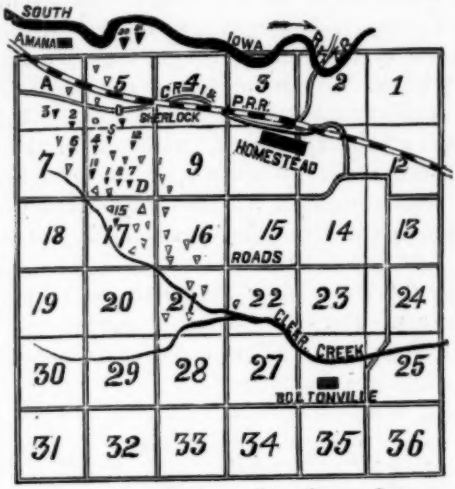


FIG. 1.—IOWA TOWNSHIP, IOWA COUNTY, IOWA.

of the "meteor-brokers;" for two dollars a pound had been offered for all these stones. Enormous profits[1] were made, creating a "meteor excitement" in the region.

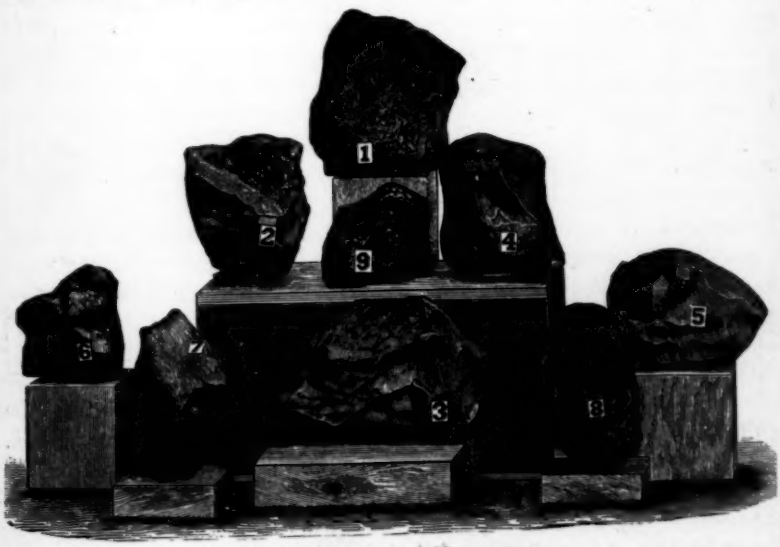


FIG. 2.—IOWA COUNTY METEORITES.

[1] One lot of stones, weighing 44 pounds, was found by Mr. Espenlaub on his land at *A*, section six, Iowa Township. The above-mentioned agent bought this of Mr. Espenlaub for $2.50, and sold it to an astronomer for $88, thus making a profit of $85.50 on an outlay of $2.50.

Mineralogy pertaining to my chair of physical science in the Iowa State University, I felt it my duty to furnish the mineralogical cabinets with good specimens of the meteorites which fell in my neighborhood. I have, through the personal and financial assistance of the Hon. John P. Irish, of Iowa City, brought together three collections, the first two of which have been photographed. The subjoined cut is a copy of the photograph of the first collection. It shows the general form of each of the specimens, numbered in the order of their weight. The photographs themselves, in one-fifth natural size, are very excellent, permitting even a close study of the granulations and surface. The above cut gives the specimens in one-seventh of their natural size.

The following catalogue gives the specimens of my collections in the order of their weight. The numbers correspond with those on the map of Iowa Township. No. 0 on the map indicates the "Sherlock Stone," the first one found:

Collection I.	II.	III.	Weight, Lbs.	Oz.	Weight in Grammes.	Presented to the Mineralogical Museum of
..	..	21	21	00	9,500	.....
..	..	20	12	4	5,761	.....
1	..	..	10	4	4,650	Paris.
2	..	..	8	5	3,793	London.
3	..	..	8	0	3,620	.....
..	10	..	7	13	3,562	.....
..	11	..	7	3	3,268	St. Petersburg.
..	12	..	6	10	3,013	.....
4	..	..	6	5	2 856	Vienna.
..	13	..	5	14	2,663	Brussels.
5	..	..	5	3	2,634	Copenhagen.
..	14	..	5	7	2,464	Haarlem.
6	..	..	5	0	2,274	Berlin.
..	15	..	4	11	2,142	Paris.
7	..	..	4	8	2,040	Christiania.
8	..	..	4	0	1,819	Stockholm.
..	16	..	3	6	1,545	Munich.
9	..	..	2	3	997	Lausanne.
..	17	..	1	7	669	.....
..	18	..	1	4	567	.....
..	19	..	1	4	560	West Point, New York.
Total.....			133	00	60,500	

But a few days ago (on June 30th) I received a dispatch from the meteorite headquarters that quite a large specimen had been found. Since, an additional, somewhat smaller stone has been found on the same section of land, namely, on section thirty of the township, directly north of Iowa Township—or about two miles north of the spot *A* in section six of the map, but a little south of the society village called Amana vor der Höhe. I have visited this place, and been kindly permitted to examine these truly beautiful specimens. The larger meteorite forms an irregular, rounded rhomb, 15 inches diagonal and 8

inches thick; it weighs 75 pounds, or 33.6 kilogrammes, and is completely covered with a black crust, i. e., a complete stone. The smaller meteorite forms an irregular rhomboid, the diagonals of which are 16 and 10 inches, while it is 12 inches thick; it weighs 48½ pounds, or 21.1 kilogrammes. One of its sides has but a secondary crust, so that another piece of perhaps 20 pounds must be found in the neighborhood. The smallest complete stone is in the possession of Mr. William Moerschel; it is a lenticular stone, weighing two ounces only. The largest stone found weighs, therefore, 624 times as much as the smallest!

The two admirable specimens just described belong to the largest meteoric *stones*[1] on record, as may be seen from the following table, which, however, is probably not quite complete below forty kilogrammes.

Meteorite of	In Museum at	Weight.	
		Lbs.	Kilogrammes.
Knyahinya, 1866	Vienna	614	279
Murcia (?)	Madrid (?)	251	114
Parnallee, 1857	London	147	67
Guernsey County, 1860	Marietta, O.	103	46.7
Juvinas, 1821	Paris	92	42
Iowa County, 1875	Amana Society	74	33.6
Iowa County, 1875	Amana Society	48.5	21.1
Ohaba, 1857	Vienna	35	16.0
Vouillé, 1831	Paris	33	15
Mezö-Madaras, 1852	Vienna	22	9.9
Iowa County, 1875	No. 21, Hinrichs's collection	21	9.5

The Amana Society has confided these two remarkable specimens to me for study. They appear to have formed but one stone when the meteor first struck our atmosphere.

The number of meteorites thus far found in Iowa County is about one hundred; the total weight is over 500 lbs., or 225 kilogrammes.

The *Iowa County meteorites* are all alike, bounded by irregular plane surfaces, indicating the usual fragmentary nature of meteorites. They are all covered with a black crust, formed during the cosmical part of their motion through the earth's atmosphere. This crust is not due to fusion, but simply to the heating of the outer layer of the stone to a red heat, as has been proved by Meunier. Indeed, the gray mass of these meteorites turns very readily black by exposure to a red heat. The surface of these meteorites shows all the ordinary impressions of meteoric stones; the finger-marks, granulations, ripples simulating the flow of fused matter, etc. The anterior side is, as commonly, deeper black than the posterior side; the latter has the smaller finger-marks.

[1] Of meteoric *irons* many of much greater weight are found in museums. The largest of all is the *Cranbourne* iron, Australia, of 4,000 kilogrammes, at the British Museum. Next in weight is the *Charcas* iron, weighing 780 kilogrammes, at the Museum of the Jardin des Plantes in Paris. The largest iron in the K. K. Hof-Mineralienkabinet at Vienna is from *Elbogen*, Bohemia, and weighs 78 kilogrammes.

These meteorites are exceedingly tough, so that it is difficult to break them up; this is due to the iron grains being partly connected by fibres and folia. Still, the nickeliferous iron is present in detached masses, or occurs sporadically in the stone. Hence these meteorites belong to the great class of *Sporadosidères* of Daubrée. In this class Daubrée distinguishes three species: those containing much, little, or but very little iron, so that it can only be recognized by a magnifier or a microscope; these species he designates as Poly-, Oligo-, and Krypto-Sporadosidères. Accordingly, the Iowa County meteorites are *Oligo-Sporadosidères*, that is, meteoric stones containing but little plainly visible metallic iron, in detached grains. I find that these stones contain seven per cent., by weight, of metallic iron. The specific gravity of these meteorites is, therefore, rather low, namely 3.57.

The fracture is very rough and uneven, showing the lustrous metallic iron, and also irregularly rounded spots of lighter gray to white on the dark-gray ground. These rounded stony concretions show very well on a ground surface of the stone; they have given rise to the name *Chondrites*, introduced by G. Rose, for this class of meteorites. I find that the grains of lighter color contain less of iron silicate, but otherwise are composed of the same minerals.

These minerals are essentially two, namely, *Olivine*, which is soluble in muriatic acid, and *Pyroxene*, which is not soluble in this acid.

Besides, the stone contains some troilite, that is, iron sulphide. The following table gives the mineralogical composition of the Iowa County meteorites, according to a number of analyses:

Non-Magnetic	Troilite	1.8	Soluble	54.7
	Olivine	52.9		
	Pyroxene	44.9	Insoluble	44.9
Magnetic	Nickeliferous Iron	7.5		

The olivine is the variety known as *Hyalosiderite*, which contains two atoms of magnesium to each atom of iron. In the pyroxene of these meteorites the same ratio of iron and magnesium obtains; hence this variety is *Hypersthene*.

The following table gives the result of my analyses of the average composition of the Iowa County meteorites:

METEORITES.	Iron.	Nickel.	Sulphur.	Ferrous Oxide.	Magnesia.	Lime.	Silica.	Sum.
NON-MAGNETIC:								
Troilite	1.1	.....	0.7	(1.5)	.....	.....	.....	1.8
Hyalosiderite	.....	.....	.....	15.2	17.5	0.6	19.6	52.9
Hypersthene	.....	.....	.....	8.8	9.7	2.2	24.2	44.9
Loss, traces	.....	.....	.....	.....	.....	.....	.....	0.4
Sum	1.1	.....	0.7	24.0	27.2	2.8	43.8	100.0
MAGNETIC:								
Nickeliferous Iron	6.6	0.9	.....	.....	.....	.....	.....	7.5
Total	7.7	0.9	0.7	24.0	27.2	2.8	43.8	107.5

A trace of manganese remains with the ferrous oxide—also a small amount of alumina. The trace of sodium is sufficient to give a brilliant line in the spectroscope; the lithium-line, while quite distinct, is not brilliant.

An extended report of my examination of the Iowa County meteorite will be published, as soon as the more careful investigation of the concretions shall have been completed, which examination is delayed for want of material. I am unwilling to sacrifice any of the fine specimens above enumerated for this purpose.

III. The Origin of Meteorites.—The researches of Daubrée and Meunier, of Paris, have demonstrated that meteorites are fragments of one or more planetary bodies, which, by some great convulsion, has been broken to pieces. Furthermore, we possess abundant evidence that the earth, in its structure, corresponds, at different depths, to the different varieties of meteorites: from those without iron (Asydères), through the Oligosidères to those consisting exclusively of nickeliferous iron (Syssydères). Hence if our earth, through the action of some cause, should be broken to pieces, these pieces would be meteorites and describe orbits around the sun similar to and near by the orbit of the earth.

But the cosmical spaces are filled with a very rare, slightly-resistant medium. Hence, the fragments being different in density and in dimensions, would be differently affected by this resisting medium. The smaller fragments and those of less density would lose their velocity of revolution around the sun more rapidly than those of greater size and higher density. In other words, all fragments would, while revolving around the sun, also descend toward the same, but at different rates: the smaller and lighter fragments would sink faster than the larger and heavier.

These terrestrial meteorites would, therefore, gradually reach the orbits of the inner planets. On Venus first would appear meteorites composed of the rocks of our earth's superficial crust, limestone, shales, quartz, granite, serpentine, etc. These would be associated with small meteorites of more dense materials derived from the deeper portions of the earth. At a later period, Venus would receive terrestrial meteorites from deeper portions of our earth, corresponding to Oligosidères. These would also be associated with small meteorites of denser materials, thus foreshadowing the third meteorite era, in which the dense masses of the interior metallic core of our earth would have sunk far enough toward the sun to reach the orbit of Venus. The mechanical problem herein involved I pretty completely solved about ten years ago.[1]

Now, it is furthermore well understood that it will be a long time

[1] "On the Density, Rotation, and Relative Age of the Planets," *American Journal of Sciences*, 1864, vol. xxxvii. "Introduction to the Mathematical Principles of the Nebular Theory, or Planetology," *American Journal of Sciences*, 1865, vol. xxxix.

before the earth is so broken up; for celestial bodies pass through their cosmical cycles in times somewhat proportional to their magnitude. Therefore, long before the earth meets this, her final doom, the moon will have been so broken up that her "lunar meteorites" will have been placed in the mineralogical museums, I trust, at less than "two dollars a pound."

Accordingly, we must look for the origin of our meteorites up away from the sun. We believe that they are fragments of some of the more minute asteroids of which hundreds yet continue to move between Mars and Jupiter. The frequent stony meteorites now falling, therefore, probably are the forerunners of a period of frequent iron meteorites, corresponding to the deeper portions of the same minute planet, the exterior layers of which have been reaching us quite frequently of late. The meteoric irons of our cabinets must have belonged to another asteroid, broken up at an earlier date than the asteroid now yielding the large and frequent crops of meteoric stones.

This is not the place for a more complete development of this view. But, as every reader inevitably would ask the question, "Whence these meteorites?" we deemed it best to give our answer.

The nebular theory fully accounts for the planetary system in its glory; but this harmony is finally followed by a breaking up and destruction of each body, which then as meteorites continue to move, truly cosmical fossils, until they find a temporary rest on the orbs which are nearer the grand centre of our world, the glorious sun.

HOUSE-VENTILATION.

"OLD FULLER"—wise, witty, and thoroughly practical—pronounced by Coleridge to be "incomparably the most sensible, the least prejudiced great man of an age that boasted a galaxy of great men"—tells us that "houses ought to be built to live in, and not to look at;" and it seems strange that a truth so obvious should require to be enunciated by an authority so great.

Since Fuller's time we have in all respects vastly progressed. We are eminently a practical people, and are undisturbed in our utilitarian pursuits by purely æsthetic proclivities. But, if we have not realized the beautiful in architecture, we ought at least to have advanced toward the attainment of utility. Unfortunately, however, the aim and development of our national characteristics have not taken the useful direction of making our houses "fit to live in"—but only to let, and to sell!

To live in a house in the Fullerian sense means, of course, existence therein under the best attainable conditions of health, ease, com-

fort, and economy. In other words, such desiderata mean proper shelter with *efficient ventilation and adequate warming.* And these now, as in the seventeenth century, are still indeterminate conditions in the problem of house-building.

If houses in Fuller's time were not built to live in, at least they were pleasant to look at. They pleased the judgment even more than the eye, for they fairly grew out of the requirements of the age, and were, in a great measure, the natural result of the ordinary materials at command. Not so the houses of the present day. Other times can boast their own styles. The castellated, the ecclesiastical, the Elizabethan, all express some idea, and are types of their own several ages and wants. But the nineteenth century, with its unlimited resources of iron and glass and its own peculiar civilization, has no distinctive style. The highest reach of architectural effort is a slavish reproduction of forms from which the spirit has lapsed with time and changed with custom. The interest attaching to a building of former ages arises partly from association and partly from the picturesque effect which age throws over it with its decay and damp. We might also say something of the poetic charm of desolation, the interest of rarity and historic truth—all, in short, which we instinctively feel can never be produced by the most perfect imitation.

But all that imagination and feeling conjure up, wherewith to clothe the rude forms of the past, are evidences of disuse and a superseded civilization. They no more accord with the full life and energy of the present age than hand-spinning does with the results of the steam-engine; and low wainscoted rooms, narrow windows, grotesque ornamentations, and rude domestic appliances, are only endurable when seen through the light of a tender, loving, hereditary pride. When, therefore, we see the constant and deliberate reproduction of old forms, and on assumed æsthetical grounds, we are justified in saying that such choice betokens the surrender of the judgment to a perverted taste; that the beauty of utility is not understood; and that the true object of house-building has yet to be learned.

The anomaly is made more apparent, if the result is less uncomfortable and unhealthy, when an architect breaks away from wholesome copying, and steals a little from various styles for the outside "treatment" of a modern dwelling. The result is a nondescript medley. Simplicity is ignored, proportion defied, fitness unthought of. For a rich man's use expense is disregarded in profuse variety; and for a poor man's dwelling—the balance is restored through the saving made in "jerry-building;" the result being what we have already stated, that average houses in the present day are built neither to live in nor to look at, but to let or to sell.

The anomaly of a medley of over-ornamentation and mixed styles in the individual villa, erected in the outskirts of large towns, is intensified into absolute mischief when such medley is applied to public

buildings and street architecture. In the former it is bad taste; in the latter it is bad taste *plus* the evils that spring from a foul atmosphere. Profuse embellishment, in a large town, is only another name for traps to catch soot.

Passing from the perverted taste shown on the exterior, we must notice the unscientific arrangements in the interior of our average domestic dwelling.

Pure air is as absolute a necessity to human beings as good food and untainted water. Bad air kills, however, by inches only, while innutritious food and foul water do their evil work with quick precision—both, in the end, leading to the same results—impaired vitality, disease, and a high rate of mortality. Nature undoubtedly has a great power of adaptation; but, under a prolonged state of unfavorable sanitary conditions, that capacity is harshly exercised. Every abnormal condition of physical existence, arising from bad air, insufficient food, or undue exposure, and producing no immediate results, necessitates the drawing of sanitary bills on futurity to be paid with heavy interest; and the very poor, from necessity, and the rich, from ignorance and apathy, spend shortened lives of prodigal thoughtlessness, ending in vital bankruptcy. Hence the crowded inhabitants of the back slums of large towns live, unconsciously, their life of lowered health, under conditions which would kill off the fox-hunting squire in a month. This depressed level of vitality and deferred penalty furnish one explanation of the general indifference to pure air.

Another cause may be found in its omnipresence and the continuity of its use. Providence has bestowed on mankind a limitless amount of pure air. It surrounds us, it is always ready without effort; its chemical composition never varies, and it costs no money. If the supply were less ample, or it could only be obtained by an outlay of money or labor, or its use were intermittent, we, no doubt, should value it at its intrinsic worth, be more jealous of its misuse, and study more closely its influence upon health.

The nineteenth-century house, however, has no special provision for the admission of fresh air, and, except in warm weather, its entrance is jealously prevented. Ventilation is change of air, and, unless scientifically arranged, and especially warmed in cold weather, such change of atmosphere means cold currents, with their attendant train of colds, catarrhs, bronchitis, neuralgia, rheumatism, and the evils that spring from them. Again, perfect ventilation means the realization, in a great measure, of the condition of air out-of-doors; and few persons, probably, have estimated the enormous flow of air requisite to effect this. The ordinary notion is, that the proper renewal of the air in a room ought to be measured by the quantity passed through the lungs of an individual in any given time. But an ounce of poison may vitiate a gallon of water; and nothing short of the removal and renovation *of the whole of the tainted portion*, as fast

as it becomes tainted, can insure perfect salubrity. Dr. Dalton estimated the average respiration of a man to be 24 cubic inches, and the average number per minute to be 20: consequently, 400 cubic feet pass through the lungs of an ordinary man in twenty-four hours; while the fallacy to which we have alluded assumes that a supply of 400 cubic feet in the room, in twenty-four hours, insures sufficient ventilation. Certainly, if any one would draw breath out of one bag, and discharge the tainted air from his lungs into another, he would always breathe good air. But it is calculated that a man will taint and render unwholesome by mixture 17,500 cubic feet of air in the twenty-four hours; for every respiration not only robs the imbibed 24 cubic inches of a certain portion of its oxygen, but it has mixed with it a quantity of carbonic-acid gas and some vapor; and theoretically, at least, the second respiration, drawn from a room in which the air is stagnant, begins the process of blood-poisoning.

The first rule, therefore, to be laid down in reference to perfect ventilation, prescribes the entire removal of the whole *stratum* of air tainted in a room by each respiration; for by no less a movement do we conceive it possible to take away the polluted air. This removal must be effected no less than twenty times per minute. Part of the expired air being rarefied by the heat of the lungs will rise, and part—the carbonic-acid gas—will fall. Twenty-four cubic inches, thus spread, may be assumed to taint a stratum, at or about a mouth of an occupant, of 18 inches. Any lateral movement would, in the case of several occupants, simply sweep the air breathed by one person close by the lips of some other; and hence we hold, as a corollary to this rule, that the prescribed movement should be either up or down, not lateral.

But the preceding calculation is based upon the minimum consumption of each person during quiescence. When talking, laughing, singing, walking, or dancing, the average respirations are, relatively, quickened, the consumption of air increased, and the necessity for a rapid change of atmosphere further enhanced. The amount of air inspired has been found to be as follows:

When lying down (say)	1.00
" sitting	1.18
" standing	1.33
" singing	1.26
" walking 1 mile per hour	1.90
" " 2 miles "	2.76
" " 3 " "	3.22
" " 3 " " and carrying 34 pounds.	3.50
" " 4 miles per hour	5.00
" " 6 " "	7.00
" riding (trotting)	4.05
" swimming	4.33

The above-ascertained accelerations of the respiratory organs sufficiently indicate the effect produced by all kinds of in-door exertion,

and incontestably prove, from increased demand, the necessity for increased supply.

This view, which we admit to be an extreme one, of ventilation requirements in dwelling-houses, may serve, at least, to impress upon many the advantage of living as much as possible out-of-doors, and of taking some regular exercise. On the other hand, it will certainly show the futility of the petty, peddling expedients adopted under the name of ventilation, when the prevailing apathy is stirred to such an extent as to cause "something to be done," which may be a little better than resting content with doing nothing at all.

What we have said of the indifference, ignorance, or error as to ventilation, has had special reference to the designers of houses "built to look at," and to sell; but a deficiency so general and complete cannot be ascribed to those only who, while they occupy the position of teachers, are compelled to take their cue from the taught. The education of public opinion is a delicate process. It is essentially one of action and reaction, requiring concurrence to initiate and coöperation successfully to work out. The illness of the Prince of Wales did much to amend house-drainage, for the torpidity of public opinion gets well aroused when royalty suffers; and the asphyxiation of a nobleman or the blood-poisoning of a bishop would, no doubt, be a wonderful stimulus to the application of common-sense to house-ventilation.

The second rule that we lay down relates to the conditions of the supply of the large volume of fresh air we have indicated as necessary for perfect health: it must be tempered—warmed. No raw, damp, frosty air of an ever-changing temperature ought to have uncontrolled and constant ingress to our dwelling. Air out-of-doors is suited to out-of-door habits. It is healthy and bracing when the body is coated and wrapped, and prepared to meet it, and when excercise can be taken to keep up the circulation; but to live under cover is to live artificially, and all essential conditions must be dealt with to suit an abnormal state, and all the evils attaching to ventilation, as generally effected, spring from the neglect of this consistency. We admit raw air, and we warm it most at the critical moment when we send it up the chimney! We freeze our backs and scorch our faces. We sit with our feet in a current of cold air, and our heads are kept in an impure atmosphere, vitiated by human lungs, the products of gas-consumption, and loaded with animal matter. We have a torrid zone bordered by the hearth-rug, and the arctic regions in the neighborhood of the windows and door. Medical men shiver at the abstract idea of violent changes of temperature, but they raise no warning voice against delicate patients being subjected to a variation of 60° in a modern drawing-room. The notion is stereotyped that night air is unwholesome. The casual admission of air during the day is no longer permitted, all known apertures are carefully closed, and, if intention

could be realized, not an atom of fresh air would be admitted during the hours of sleep. So little is the necessity for good air understood, that we find an able writer on health sanctioning, if not advocating, sleeping with the mouth under the clothes. His argument is that birds sleep with their heads under their wings, and he might have added, many animals with their noses buried in their fur; forgetful, however, that the feathers (and hair) form a natural respirator to *warm and equalize the temperature* of the air that passes freely through. There is therefore no analogy in a process for warming a constant supply of perfectly fresh air, and one for breathing the same air over and over again, and charged *ad nauseam* with organic impurities. Miss Nightingale approaches the subject of night air from the side of reason, and common-sense, and experience. She says:

"Another extraordinary fallacy is the dread of night air. What air can we breathe at night but night air? The choice is between pure night air from without and foul night air from within. Most people prefer the latter. An unaccountable choice. What will they say if it is proved to be true that fully one-half of all the disease we suffer from is occasioned by people sleeping with their windows shut? An open window most nights in the year can never hurt any one. This is not to say that light is not necessary for recovery. In great cities, night air is often the purest and best air to be had in the twenty-four hours. I could better understand in towns shutting the windows during the day than during the night for the sake of the sick. The absence of smoke, the quiet, all tend to making night the best time for airing the patients. One of our highest medical authorities on consumption and climate has told me that the air in London is never so pure as after ten o'clock at night."

These are the words of sound sense and experience. We shall only have to add to them, by-and-by, that it is not necessary to encounter the oftentimes great risk of sudden changes in temperature during the night, if we arrange one principal source of admission day and night to the house, and warm the air admitted. We may further remark that if there be the least ground for shrinking from night air, it is because of the often sudden and unforeseen change in the temperature, the very point overlooked in moving from fireplace to window in modern drawing-rooms.

Latterly some attention has been directed to a plan for diffused ventilation, adopted by Mr. M. Tobin. This plan consists of a series of vertical pipes placed along the walls, delivering fresh air in an upward current. In a multitude of pipes there is safety—much more so than in a multitude of counselors on this subject. Commenting upon this plan of course many critics claim priority of invention, and superiority in their modes of application, and the interests of the public thus go to the wall without any result. It is a pity that it cannot be made intelligible that whoever first opened a window or a door, for the express purpose of admitting air, originated ventilation; and that whoever first made a deeper recess for the lowest sash-bar, so that when the

window was slightly raised the opening would only be where the two sashes overlap, and the admitted air thus thrown upward, originated Mr. Tobin's principle of getting the admitted air diffused in the upper part of the room; and that whoever did this in a room, with apparently no prearranged outlet, first realized the process known by the name of "Tobination."

We believe it was Sydney Smith who declared that if any one in London should stare continuously for a few minutes at the clouds he would be forthwith surrounded by a crowd of gazers, no one knowing why he gazed, intently interested in nothing, and quite unaware that the secret of his sympathy was the inspiration that makes the ploughman whistle—want of thought. For ourselves we do not undervalue this gregarious vacuous tendency. First catch your hare, says good Mrs. Glass, as the initiatory step to cook it. First secure your audience in this matter, as the absolutely necessary preliminary to convince the understanding and stimulate to action. The excitement and satisfaction felt at the recommendation of a mode of ventilation, because perfectly simple and thoroughly efficacious, and yet so obviously similar in its results to window-ventilation, we are disposed to hail as an encouraging symptom, although such satisfaction seems wonderfully like that felt by good King George when he adopted the simple expedient, *under advice*, of shutting his mouth to keep out the dust and dead flies on a windy day!

If the sanction of royalty helped to promote so proper a mode of excluding dust and insects, so, similarly, a report upon "Tobination," signed by six peers and gentlemen, and published in the *Times* on May 16th, may help to recommend the admission of fresh air as a useful method of ventilation. The phenomena attested are certainly surprising in their concurrence, and we cannot but regret that these noblemen and others did not simply state their opinion, which every one would respect, without assigning proofs which most persons must question. "Nae plea is best," say the cautious Scotch, and we are further reminded of the dictum of a wise old friend, "My reasons may be all wrong, but I know that my conclusion is quite right." Now, if the report had simply attested the fact that at a certain time the atmospheric condition of the ward was good, this would have been "nae plea," and best; for the *raison d'être* of the said good atmospheric condition seems to us to be contradictory. What the said six found they thus describe:

"In the ward of St. George's Hospital ventilated by Mr. Tobin's pipes we found the following phenomena:

1. Pure air agreeable to breathe.
2. Absolute equality of temperature at every level of the room, in which gas had been burnt for some time.
3. Freedom from all draught of air. With a lighted taper we could detect no current in any portion of the room."

As we have already indicated, this statement in reference to "the last new thing" in ventilation is, to say the least, puzzling. It virtually asserts the instantaneous and complete mixture of cold air with air heated by and with the gaseous products of combustion, and a simultaneous and necessarily rapid diffusion throughout the entire space of the ward in St. George's Hospital; and that this rapid mingling, mixing movement of particles is done without any perceptible mingling, mixing process, or movement whatever! It thus virtually states that the rapid change of air which alone constitutes perfect ventilation is effected without any ascertainable movement of such air. If such concurrent phenomena be really, as stated, "matters of fact," and not, as we take them to be, the honest but erroneous belief of persons not accustomed to scientific and chemical research, we can only ejaculate like Dominie Sampson—"Pro-di-gi-ous!"

We have so far played the part of critic. We have stated the abstract requirements of perfect ventilation, and have assumed that such requirements are inapplicable to most modern houses. We have condemned the general ignorance and indifference to the proper supply of one of the essentials to existence, and have ridiculed the miserable expedients which pass current under false pretenses. We have further discussed the theory and practice of ventilation mainly distinct from its almost inseparable connection with house-warming. But, unless we are prepared to supply our houses by mechanical contrivances, such as fans, etc., it is impossible practically to consider the thing to be done apart from the obvious means to carry it out; and it is in heat that we find the ever-present and most applicable motive force. If we can give to our houses an average temperature of 55° with local exceptions somewhat in excess of this average, we make them, and particularly the lofty slip of building forming the common London street-house, into a warm air-shaft, having an upward draught. If we can properly arrange and control the entrances and exits of the necessary air, and secure that the supply be ample and the conditions of its motion innocuous, we have solved the problem of practical ventilation.

Any one who can effect this solution will be fairly entitled to the gratitude of all ranks and classes of society—excepting, perhaps, that of the medical profession! And whoever does this by a simple method—without using any scientific complications, and requiring no surrender of the average comprehension to the keeping of mechanical experts—who can reconcile sentiment with common-sense, and economy with the Epicureanism of our present civilization, and who yields no vantage-ground to servantgalism to demand higher wages, nor otherwise trenches upon the time-honored privileges of the servants' hall (to do little in the easiest way)—will have established a claim to social gratitude. The danger he will incur will be in the shape of a testimonial, which will most likely make Art shiver, and the descend-

ants of the receiver despise the ability of the progenitor which handed down to them a thing they hate to keep and dare not sell.

There is a hades, moreover, for inventors and teachers, as well as a paradise. Like people who write books, they give their enemies an advantage. The detailing of their plans is like dragging a coat at Donnybrook Fair. They invite attack from every one whose interests they jostle, or whose pride they wound; and hurt feelings are a species of cantharides to hostile criticism. Altogether, the man who steps ahead of the crowd is marked out for assault. He quits a comfortable insignificance, and, bidding for fame, usually achieves failure and gains ill-will.

Clearly comprehending the possible results, we nevertheless venture to speak of a combined system of warming and ventilation which, from experience, we can state has proved successful. It aims at surcharging a house with warm air, in reversal of the present custom of exhaustion. Ventilation is movement of air, or draughts; and cold draughts are dangerous, and expensive. We therefore warm our draughts, and, in lieu of enemies, make of them friends. By superseding the necessity for it, we put bad workmanship into its proper category of things to be avoided. A house being full of warm air, misfits and scamped work form outlets, not inlets, and are no longer mischievous. By generating heat in the most scientific way, and retaining the bulk of it in the dwelling instead of sending ninety per cent. up the chimney, we enlist the sympathy of the thrifty; and, by considering the question from the house-maid's point of view, we avoid irritation and bickering, and, in spite of new-fangled arrangements—

"We still have peace at home."

Our plan is simply this: If the basement be dry and eligible, we form therein a fresh-air chamber by boarding off or otherwise making it, if possible, under the staircase-hall. We have it carefully cleansed, whitewashed, and purified. We jealously isolate it from any illicit communication with the usually damp and fusty atmosphere of ordinary basement premises, but give to it an ample communication with the outer air, being careful that the supply is drawn from untainted sources. Between this chamber and the hall we also arrange a communication through a large ornamental iron grid.

Immediately under the grid in the air-chamber we have placed a large slow-combustion coke or German stove, and to prevent dust, noise, or effluvium during such lighting, we recommend a slide, or trap-door opening downward, to cut off communication until the fire has burnt up. *Voilà tout!* This simple arrangement, which does not merit the name of apparatus, sets a system of ventilation to work for which we claim the merit of efficiency, by merely lighting and adjusting the stove-fire. Of course everybody has thought of this, and we dare say some persons have tried some such arrangement; but we question whether it has not been hitherto too simple for enthusiasts, too prac-

tical for theorists, and in its results too philosophical for "practical men."

A grid with a clear opening of two to two and a half feet square, through which air is sent at the rate of three feet per second, will change the entire atmosphere of an ordinary London house every hour; and a good-sized coke or well-constructed German stove will heat this volume of air from 65° to 70°, and maintain a temperature throughout such house of 50° to 55°.

The bulk of the heat so generated will be utilized and diffused. The excessive loss of heat from fireplaces will be changed to use, and economy will be the rule instead of a waste—excessive, continuous, and expensive. And the whole of it will be in substitution—not in excess—of an undisturbed open fire-grate consumption of fuel, and this by a process of natural selection and persuasion. With a fairly equable temperature of 50° to 55° throughout the house, and highest where now it is usually lowest—the hall and passages—the demand for large open fires subsides. Small fires become the rule, and their going out the difficulty. There will be no dread of draughts from open doors; no peevish injunctions to "shut that door;" no huddling over a hot fire, scorched on one side and chilled on the other; no breathing at one moment of air at 100°, and the next, and without preparation or much gradation, one of 40°. In short, "the bull will be taken by the horns" *and tamed.* We have made friends of our foes, and we may cry Eureka!—for the problem will be solved!

Now for the possible objections. We shall probably be told that stoves are unwholesome—that they spoil the air and make the warmed space "close." Our reply is, that stoves in unventilated rooms do all this, and more. They are usually unsightly, and they—even the most economical—rob the room of the bright, cheerful, moral influence of warmth with light. But none of the objections to which stoves are liable attach to their use under the arrangement we advocate. The stove is not placed in an unventilated room, *but in a strong draught.* No particle of air ever gets warmed twice over. None is *forced* into contiguity with the heating surface. It takes up as it passes that surface its modicum of caloric, and wings it way to impart it to all and every thing of a lower temperature than itself; and finally it escapes, when fairly deprived of it, by nicks and crannies and illegitimate outlets, as well as by those prearranged for the best effect. Hence there are no whistling shreds of frosty air, harbingers of colds, catarrhs, toothache, earache, and neuralgic inflictions; no "sulphuring" from down-draughts in unused bedroom-fires; no shiversome "draughts" from open doors. By admitting air round about our heat-generator, full, free, and unconfined, we adopt the principle of the steam-engine governor. If the stove be overheated from negligence, the draught becomes quicker, the particles of air are heated sooner, but not necessarily much more. If the stove-fire is allowed to get low, each par-

ticle of air lingers longer, until warmed enough to set off on its errand of ventilation and warming. Variations of heat in the stove quicken or retard the unconfined and full current rather than vary the heat of each particle, and we claim to accomplish by a self-acting process a fair uniformity of temperature.

It will, no doubt, be urged that a house kept up to 50° and 55° makes people "delicate;" that they "catch cold" when they go out; that a hardening process is healthy, and so on.

Our reply is, that a uniform temperature of 50° and 55° is natural and healthy. That the maintenance of this temperature in winter must be a question of clothes or fuel on the one hand, or of depressed functional action on the other. That the loving care which prescribes a cold bedroom and a hot, sweltering bed is of the nature of that kindness that kills. That children buried in blankets realize Prince Bismarck's coarse threat to the Parisians: that their delicate skins become overheated and relaxed while they are irritated by perspiration; at the same time that the most delicate tissues of all, in the lungs, are dealing with air abnormally frigid. Fevered or relaxed, the poor little victims of combined ignorance and kindness toss and dream, troubled under a mass of bedclothes, while the well-meaning mother, "wrapped in her virtue," and soothed by a bedroom-fire, slumbers peacefully through the working out of the sad process of "the survival of the fittest."

The only other objection to be urged against the use of a stove is the small part that the combustion of the fuel in it plays in the matter of ventilation. As the ventilation by means of an open-air fireplace is the principal cause of the waste of heat up the chimney, we cannot consider this gain from arrested waste as an objection, except in extreme cases of stove-misplacement. As, in the plan we are considering, the stove is the agent to supply a very large quantity of air, the plea that it does not abstract any large volume, we take to be an advantage, not an evil. The open fires become the chief diffusers, drawing the injected air within and then out of each room. We concede their employment to the claims of luxury as wasteful adjuncts, but minister still to comfort and luxury. At the same time we legitimatize their action and leave them free to work. We are no longer at enmity with Nature; no longer spoiled children of civilization, struggling against "what is good for us;" but, freely accepting the imposed conditions of an artificial life, we use reason and common-sense to make them the best of their kind. We cook our air as we cook our food. Both in a raw state are objectionable. Both subjected to the modifying influence of heat become pleasant ministers to our daily wants. One generates the blood which is the life, the other is its purifier and renovator. The use of both is health, vigor, and enjoyment; the abuse of either counts up largely in the account we have to pay for what of evil there is in the world.—*Abridged from Westminster Review.*

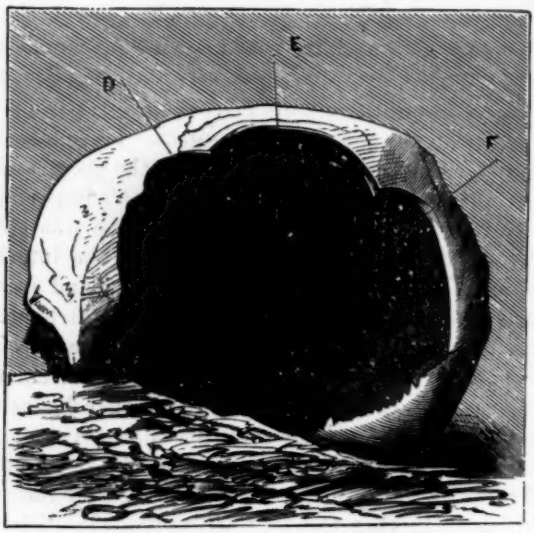
CRANIAL AMULETS.

By Dr. J. BERTILLON.

TILL the other day nothing was known that would indicate the existence of a religion among the people of the Stone Age. But a little over a year ago there were discovered clear traces of a *cultus*, the most ancient of which we have any idea. I propose here to narrate how we gained our first knowledge of the gross and oftentimes savage superstitions of our early ancestors. This important discovery was made by Dr. Prunières, of Marvejols. As he was cleaning some skulls from the dolmens of Lozère, he found in the interior of one of them a bone disk carefully polished on the edges, and evidently made of a fragment of a cranium, perhaps of the parietal bone. The skull in which this disk was found presented a great hole, through which it might have passed; still evidently it had not come from the part destroyed, being considerably thicker than the other bones of the skull, and, furthermore, differing from them in color. On examining this cranium at the point where it was mutilated, the edges of the opening were found to be carefully polished and beveled on the external surface, and it was plain that the hole itself, like the disk of bone, had been wrought by the hand of man. Was it also man who put the bone disk inside of the skull? One might think at first that it was the effect of an accident similar to that by which the beads of a necklace often drop into the skull; but, when other pieces were discovered similar to that described, it could not be doubted that it was the hand of man which placed the disk of bone in the skull. What was the intention? It is impossible to say with certainty, but it is difficult not to believe that the practice was coupled with a religious idea.

A number of skulls found by M. Prunières presented an opening more or less large, but contained no bone disk. These openings are often the size of a silver dollar, of variable form, but usually circular. That which has excited the greatest astonishment, however, is the fact that these perforations had been made during life, for their beveled edges had evidently commenced to cicatrize; often, indeed, the loss of substance was entirely restored. The *savants* to whom M. Prunières communicated his discovery then remembered that in many skulls they too had observed similar holes, with the edges more or less cicatrized. Up to that time they had supposed that they resulted from strokes of a hatchet dealt by an athletic arm, just as now a sabre often removes a portion of the skull. But what strength are we to imagine the men of that time to have possessed in order to make such terrible wounds with a simple stone hatchet? Hence the explanation offered was not very satisfactory. All doubts were set at rest by the invaluable discoveries of M. Prunières, as interpreted by himself with rare

sagacity. The theory of these holes being the result of a blow from a stone hatchet is indeed extremely improbable in itself; then, too, why should skulls so disfigured be found in such numbers at Marvejols?



PERFORATED CRANIUM FROM LOZÈRE.

Evidently these perforations were made by the hand of man, and with some design; or, to speak more plainly, these people trepanned one another. For what motive did they practise this painful and often fatal operation? Numerous hypotheses have been put forward. Some suppose, with a fair degree of probability, that it had a therapeutic object. The trepan, indeed, has been practised from the most remote antiquity. Hippocrates speaks of it as an operation widely diffused; and, although the father of medicine is in the habit of citing authorities, and of naming the inventors of operations, he does not tell us the name of the originator of trepanning, which leads us to think that his name was not known, because it was lost in the night of time. It is true that the name, from τρεπω, *I turn*, indicates that, when it was admitted into Greek surgery, it was performed, as it is now, by the aid of a centre-bit; still, in primitive times rude methods were no doubt employed. The trepan was in great repute among the Greeks, and during the middle ages was resorted to for the cure of a number of maladies. The same practice widely prevails at the present time among uncivilized races.

M. le Baron de Larrey, in a note communicated to the Paris Academy of Medicine, relates that the Kabyles still frequently practise the operation, making with a saw four cuts in the shape of a parallelogram. General Faidherbe has sent to the Laboratoire des hautes

Études two skulls from Roknia, Algiers, with traces of this operation. Mr. Squier presented to the Society of Anthropology a skull from an ancient Peruvian grave, upon which are distinctly seen the eight extremities of these saw-cuts. The traces of inflammation around the bone prove that the operation was performed about a week before death. If the person had survived some years, the traces of incision would have been effaced, the four angles would have become rounded, and the result would have resembled those which we now find upon the skulls of Lozère.

M. Chil related, at the Congrès at Lille, that there had been found a perforated skull resembling those discovered by M. Prunières in the Canary Islands—a fact of great importance, if confirmed, for it would indicate that these islands were peopled by African negroes.

The *Medical Times* assures us that the medicine-men of the South-Sea Islands practise, with a bit of glass, trepanning for troubles of the head, such as vertigo, neuralgia, etc. The remedy consists in making a T-shaped incision in the scalp, and scraping the skull with a fragment of glass, until the dura mater is reached, and a hole made one inch in diameter. In the minds of these savages the healing art is mixed up with a multitude of singular religious ideas. In their eyes the maladies of the body are caused by demoniacal possession. Therefore, when one suffers in the head, we must open a passage to let the demon out. It was thus that Jupiter, suffering from headache, escaped the malady by causing Vulcan to strike him so violently that Minerva, Goddess of Wisdom, sprang from the opening.

Hence it may be that, for medical reasons, the men of the Stone Age trepanned the skull. But this does not account for all the facts. Why trepan the dead? Why introduce into some skulls the round plates of bone? It is clear that the healing art had nothing to do with these *post-mortem* operations, and that here our forefathers were simply acting in obedience to some religious ideas which it is hard for us to imagine.

In the first place, we would observe that, in all probability, these people had a religion. M. Joseph, of Baye, has communicated to the Société d'Anthropologie a discovery made at Baye (Marne) of artificial grottoes excavated in the chalk during the Neolithic Age. He saw upon the walls of these caverns rude and almost shapeless sketches representing divinities in human form; and in these same caverns he found skulls perforated similarly to those of M. Prunières. Upon these grounds we may safely argue the existence of a system of religion. It has been observed that all the operations of trepanning were performed either upon infants or upon youths. "Why were not all ages subject to it? why only infants or youths? I hazard the conjecture that it was connected with some superstition, that it formed a part of the ceremony of initiation to some priestly order. This, it is true, presupposes the existence of a religious caste; but there is no doubt

that the neolithic peoples had an organized religious system. These rude sculptures, ever repeated exactly, which represent a female divinity upon the walls of the grottoes of Baye, even prove that the religion of Neolithic times had risen to the height of anthropomorphism. Now, a clearly-defined deity, a god in human form, must have priests that are regularly initiated; and a surgical initiatory rite recurs over and over again even among civilized peoples. Is it objected that the cranial mutilations were of too dangerous a character to be practised in religious ceremonies? But *per se* trepanning is not a dangerous operation. Very frequently, no doubt, it is fatal, but the reason is, because it is resorted to only in the last extremity. It is not the trepanning which kills the patient, but the cerebral lesions, which we seek to relieve in this way. Apart from these complications, its dangers are not very great. On the other hand, religious enthusiasm knows no bounds; and if certain deities exact human sacrifices, certainly those should be considered lenient who require of a man only a piece of his skull. What is piercing the skull, compared with disemboweling? And yet it is known that, among the negroes of Western Africa, certain individuals, to secure initiation in sainthood, and to prove the virtue of their amulets or *gree-grees*, open their bellies with their own hands, pull their bowels out, put them back, and sew themselves up. Many succumb to this butchery, but others rally and become the saints of their tribe." ("Bulletin de la Société d'Anthropologie," 2e série, tome ix., p. 199.)

Doubtless those who survived the piercing of the skull became equally worshipful personages, held in honor during their lives and after their deaths. Out of their sacred skulls were cut plates of bone, as shown in the engraving. They were then kept as sacred relics, or even worn as amulets, for many of them are pierced through the centre evidently with the view of suspending them. The skull in the figure has undergone three mutilations, *D*, *E*, and *F*, doubtless for the purpose of making amulets. Nor ought we to deride this superstition which attaches supernatural virtue to a bone from the human head: as late as the last century, a powder made from certain bones of the cranium used to be prescribed as a cure for epilepsy. It has been remarked that all the skulls in which disks of bone were found, were pierced during the life of the individual. If our hypothesis be true, the only ones honored with this practice would have been those consecrated to the service of the gods. If, on the other hand, motives be sought wherefore the dead should be thus honored, we are irresistibly conducted to their steadfast faith in the immortality of the soul. A person who had been trepanned comes to die—one or more pieces are cut from his sacred cranium for amulets or relics; but, inasmuch as the man could not live in another world with a mutilated skull, another piece of skull is given him to make him whole, when he reaches the abode of the blest.—*La Nature.*

THE USE OF NARCOTICS.

THE indulgence in narcotics—something to dull, stupefy, and soothe the nervous system—is a predominant human weakness. Nature has been ransacked for narcotics. Tobacco, opium, betel-nut, Indian hemp, even some kinds of fungi, are employed for the desired object. When tobacco was first introduced into Europe, its use was nearly everywhere looked upon with dislike by the authorities. The efforts that were made to suppress it amounted to nothing less than persecution, and their want of success furnishes a curious illustration of the uselessness of legislative interference with the individual's legitimate freedom of action. It serves also to illustrate in some measure the strong hold which the taste for narcotics obtains over the mind, especially as tobacco is one of the mildest narcotics in use. Among ourselves, not to mention King James's well-known "Counterblast," many petty restrictions were laid on the sale of tobacco during that monarch's reign, and the import duty was raised from twopence to six shillings and tenpence a pound. In England and elsewhere, remonstrance and penalties were equally unavailing. Tobacco made its way steadily into favor, and is believed to be now in use among not less than 800,000,000 of the human race.

Measures of a severe nature have been tried in China to check the use of opium, and have been quite as unsuccessful. However apathetic the Chinese may be in respect to most things, they will not submit to the withdrawal of their favorite narcotic. But in case of so dangerous a poison, some restrictions are as much needed as they are on the sale of spirituous liquors among ourselves; for the effects of habitual excess are not less deplorable than those of habitual drunkenness. Of forty prisoners confined in the House of Correction at Singapore, thirty-five were found to use opium; and of these, seventeen, who had been in receipt of eighteen shillings a month as wages, spent twenty-four shillings for opium, the difference being obtained by theft. From a sanitary point of view, the results are equally sad. The confirmed opium-eater in the East seldom lives beyond the age of forty, and may be recognized at a glance by his trembling steps and curved spine, his sunken, glassy eyes and sallow, withered features. The muscles, too, of his neck and fingers often become contracted. Yet incurring even this penalty will enable him to indulge his vice only for a certain length of time. Unlike the healthy enjoyment which we derive from our appetite of hunger, and which Nature herself renews periodically, the enjoyment of the opium-eater gradually diminishes as his system becomes habituated to the drug. From time to time he must increase the quantity which he takes, but at length no increase will produce any effect. Under these circumstances he has

recourse to a dangerous expedient: he mixes a small quantity of corrosive sublimate with the opium, the influence of which is thus for a time renewed. Then these means also fail; when the victim must bear the miserable condition to which he is reduced, until probably, sooner or later, he sinks into the grave. On the excitable temperament of the Malays and Javanese, a strong dose of opium causes a state of frantic fury amounting almost to madness, and this often ends in that homicidal mania which has been called "running amuck;" in other words, in the individual attacking with his crease or dagger every one whom he meets, so that it becomes necessary to shoot him down with as little compunction as we do a mad dog. In Java, opium is not allowed to be sold except in an adulterated form, the risk of these evil consequences being thus in some measure lessened.

So far as the effects of opium on the system are concerned, it is almost entirely a matter of indifference in what way the drug is used. Whether it be taken in the solid form of pills, in the liquid form of laudanum, or inhaled from a pipe as heated vapor, it speedily exerts its pernicious and almost irresistible influence over the mind; so that few possess the iron will needed to relinquish the habit when it has once been fairly acquired. How completely even the most intellectual and cultivated minds may become enslaved was well illustrated in the cases of Coleridge and De Quincey, whose highly-colored descriptions of their experiences are said to have been productive of much evil among the educated classes of this country. These descriptions must not, however, be regarded as safe criteria of the usual influence of opium on the colder temperament of the North European. According to Dr. Christison, it seldom produces a more striking effect on the Anglo-Saxon constitution than the removal of torpor and sluggishness, thus rendering the opium-eater a pleasant and conversable companion; but these small advantages, in turn, are purchased by a period of subsequent pain and depression, the misery of which it would be difficult to exaggerate.

Opium, besides acting as a narcotic, possesses a remarkable power as a restorative. By apparently checking the natural waste of nervous energy, it enables the system to support fatigue, beneath which it must otherwise inevitably have sunk. For this reason it is much used by the Halcarras, the palanquin-bearers and messengers of India, who journey almost incredible distances, furnished with nothing more than a bag of rice, a little opium, and a pot to draw water from the wells. The Tartar couriers also use it to sustain them, when compelled to travel night and day in crossing the arid deserts of Central Asia; and in some parts of the East it is administered as a restorative even to horses.

It is difficult to come to any definite conclusion as to whether the physical character of Eastern races who habitually use opium as a narcotic has deteriorated in consequence. No doubt the general be-

lief is that even moderate indulgence must necessarily be injurious, and it is easy to point to the enervated character of the Turks and other Oriental races as a probable result of the habit. But at the same time it is a disputed point among physiologists how far this belief correctly represents the truth. The opinions of many men well acquainted with the East might be quoted in opposition to it; for example, Dr. Eatwell, formerly of the East India Company's service, in writing to the *Pharmaceutical Journal*, has affirmed that, as regards the great mass of the Chinese, no injurious effects of the opium they consume can be noticed, the people being generally a muscular and well-formed race. Dr. Macpherson has given similar testimony in respect to the Chinese, and Dr. Burnes in respect to the natives of Scinde and Cutch; while, on the other hand, Dr. Little, of Singapore, is of opinion that the native population of that island would be in danger of becoming extinct from the use of opiates, were it not constantly recruited by immigration. It is, however, evident that the question can only be satisfactorily answered by knowing the real extent to which opium-eating prevails among the different Eastern populations, and of this no reliable statistics can be obtained.

There is a similar want of definite information in respect to the United Kingdom. Attention was partially drawn to the subject so long ago as 1844, by an inquiry that was made into the state of large towns in Lancashire; and since that time there is every reason to believe that the evil has largely augmented. The increase in the quantities of the raw material imported would alone be sufficient to render this probable; for, while in 1852 the importation amounted to 114,000 pounds, it had grown to 356,000 pounds in 1872. No doubt a large portion of this enormous quantity is employed in the manufacture of morphia or other alkaloids, and is either exported or employed for legitimate medicinal purposes; but it is difficult to account for an increase in twenty years of 200 per cent., except on the supposition that the drug is *more largely used as a narcotic than is generally believed*. The facility with which this form of vice can be concealed renders direct evidence on the subject difficult to obtain; but such evidence as can be procured tends to prove that the above supposition is correct. We have recently been informed by the medical attendant to the workhouse in one of our larger cities, that a week rarely passes without a case of opium-eating coming to his knowledge among those who seek admission to the workhouse; and that he has known women, when suffering from the depression consequent upon their enforced abstinence, even go down on their knees to beg that he would administer to them an opiate. Again, there is reason to believe that opium is a favorite stimulant with many underfed and overworked artisans and laborers; and from inquiries made by parochial officials, clergymen, and others, this would appear to be especially the case in agricultural districts. In the fenny districts of Lincolnshire, a belief being preva-

lent that opium acts as a preservative against the effects of a damp climate, many of the inhabitants have in this way become addicted to its use.

Another and even more reprehensible form of the opium evil among the lower classes is to be found in the practice of administering soothing mixtures to young children for the purpose of keeping them quiet. In one instance, a mother, because her child was unwell, has been known to place a piece of crude opium in its mouth to suck, the death of the child being naturally the consequence; and though cases of such gross and culpable ignorance as this are no doubt rare, it is certain that the administration of soothing sirups and cordials is too commonly resorted to. In large manufacturing towns, where mothers are often employed in factories during the day, their infants are frequently placed for the time in the care of nurses; and these women seldom feel any compunction in administering an opiate to a child who is troublesome. It cannot be too widely known how greatly such a practice tends not only to the direct increase of infant mortality, but also to the permanent injury of the constitution, by inducing convulsions and other similar nervous diseases.

Opium in one of its forms enters largely into the composition of many of the pain-killers and patent medicines so freely advertised for domestic use in the present day, and for this reason the greatest care is needed in having recourse to any of them. Taken, perhaps, in the first instance, to alleviate the torments of neuralgia or toothache, what proves to be a remedy soon becomes a source of gratification, which the wretchedness that follows on abstinence renders increasingly difficult to lay aside. The same must be said of narcotics, such as bromide of potassium and hydrate of chloral, frequently resorted to as a remedy for sleeplessness: the system quickly becomes habituated to their use, and they can then be relinquished only at the cost of much suffering. Indeed, the last-mentioned of these two drugs obtains over the mind a power which may be compared to that of opium, and is, moreover, liable to occasion the disease known as chloralism, by which the system ultimately becomes a complete wreck.

Looking at the whole question of the medicinal use of narcotics, it is perhaps not too much to say that they should never be employed except with the authority of a competent medical adviser.

Turning again to the narcotics of savage or but semi-civilized races, we find a species of fungus (*Amanita muscaria*) employed by the natives of Kamtchatka and the adjoining provinces of Siberia. It grows plentifully in parts of Kamtchatka, and is there generally prepared for use in several ways. The inhabitants either gather it during the hottest months, and hang it in strings to dry in the open air, or leave it to ripen and dry in the ground, when it possesses stronger narcotic qualities. Small-sized specimens, covered with warty excrescences and deeply-colored, are also considered more valuable than

the smooth pale ones. Sometimes it is eaten in soups and sauces, or is taken mixed with the juice of the whortleberry; but the more usual method is to swallow it whole, rolled into the form of a pill, and a single large-sized toadstool thus taken is sufficient to cause the narcotic effects during a whole day. These bear a very close resemblance to those of ordinary intoxication, and, like them, often end in complete insensibility. Whatever may be the natural temperament of the individual shows itself with unusual distinctness. A man who is fond of music or of talking will be constantly singing or chattering; and secrets often thus slip out, the disclosure of which is the source of much subsequent trouble. In this form of narcotism, too, the power of estimating the size of objects is temporarily destroyed, so that a man wishing to step across a straw or a small twig will raise his foot as though about to step across the trunk of a tree.

The Siberian fungus is not the only narcotic in which this last peculiarity is found. Similar erroneous impressions are caused by the Indian hemp, which, though it is used in Southwestern Asia, and indeed in the Brazils as well, is more properly the narcotic of the African Continent, where it is known to the native races from the Mediterranean to the Cape of Good Hope. It is the same plant that is grown in Europe for the sake of its valuable fibre; for, though probably indigenous to India, it is able, like the potato and the tobacco plant, to adapt itself to a great variety of climates, and is grown even in the north of Russia. Its narcotic virtues depend on a resinous substance contained in the sap; and this is much more abundant in tropical climates than it is in temperate. Indeed, the European plant is almost devoid of it, though it possesses a strong odor which has been known to make people ill who have remained long in a hemp-field. Thus, when the dried plant is either smoked or eaten, its effects are both rapid and powerful. In Morocco, where the dried flowers are generally smoked, a single pipe not larger than an ordinary tobacco-pipe is sufficient to intoxicate. Among the Arabs and Syrians, the usual method is to boil the leaves and flowers in water mixed with butter to the consistence of a sirup, which is called *hasheesh*, and, as it has an extremely disagreeable taste, is eaten in a confection of cloves, nutmegs, and other spices. But however the narcotic may be used, the pleasure it affords is much the same in character. It has been described as consisting in "an intense feeling of happiness, which attends all the operations of the mind. The sun shines on every thought that passes through the brain, and every movement of the body is the source of enjoyment." But the most remarkable peculiarity of the Indian hemp has yet to be mentioned: a dose of the resin has been known to occasion that strange condition of the nervous system called catalepsy, in which, notwithstanding the force of gravity, the limbs of the unconscious patient remain stationary in whatever position they may be placed.

The use of the coca-tree as a narcotic in Peru and Bolivia is of very great antiquity. When the Spaniards landed under Pizarro, they found the natives chewing the dried leaves, in exactly the same way in which they have continued to chew them down to the present day. Efforts were indeed made, soon after the subjugation of the country, to put a stop to the practice, for the plant had acted an important part in the Peruvian religious ceremonies, and its use was looked upon by the conquerors as an obstacle to the spread of Christianity. Nevertheless, the Indians persevered in spite of every prohibition and severity. Before long, too, the owners of mines and plantations discovered that it was to their interest to connive at the habit, as, with its aid, their laborers were able to perform more work on a given quantity of food than they could do without it. It has thus gradually become the universal custom to allow from fifteen to thirty minutes, three or four times a day, for the purpose of chewing. At these times the first object of the Indian is to make himself as comfortable as possible, for the coca fails to produce its effect unless the chewer be perfectly quiescent. He stretches himself at full length in the shade, on a couch of dry leaves or soft turf, and, rolling a few of the coca-leaves into a ball, conveys them into his mouth; adding immediately, to bring out the full flavor, a small quantity of unslacked lime, or of the alkaline ashes of certain plants. When thus engaged, the apathy he displays to every thing around him is something marvelous. No entreaty on the part of his employer will induce him to move, and, if he be a confirmed *coquero*, he is indifferent even to drenching rain or the roar of wild animals in the neighboring thicket. In what way the pleasures of the coca-leaf manifest themselves is not known, but they must evidently be of a very seducing kind, thus to render men insensible to personal danger.

Notwithstanding the wide prevalence of the use of narcotics, little or nothing is known of the way in which their different effects are produced on the system; and the problem is complicated by the number of active substances that enter into their composition. Opium, besides other more ordinary ingredients, contains no fewer than eleven peculiar organic compounds, all of which are believed to share in producing its usual effects. It has, however, been noticed that many symptoms of narcotism bear a close resemblance to those of insanity. The wild laughter of a man under the influence of the deadly nightshade cannot be distinguished from that of a manaic, and the false impressions as to the size of objects, caused by the Indian hemp and the Siberian fungus, are a permanent feature in the malady of many lunatics. It has been suggested by Dr. Carpenter that much light might be thrown on the connection between the mind and the body by studying the phenomena of drunkenness, and it seems probable that those of narcotism in different parts of the world might be made to yield equally rich results. Of one thing we may be quite certain. The use

of tobacco has become a positive vice. The wastefulness of money which it causes, without a compensatory advantage, is alone deplorable.—*Chambers's Journal.*

SKETCH OF PROFESSOR HILGARD.

WE this month present to our readers the portrait of JULIUS E. HILGARD, First Assistant of the United States Coast Survey, and President of the American Association for the Advancement of Science at the meeting in Detroit, which takes place on the 11th of August of the present year. Mr. Hilgard was born in January, 1825, in the town of Zweibrücken, in Bavaria, where his father held the position of Judge of the Court of Appeals for the Palatinate of the Rhine. At the age of nine years he came to the United States with his father, who settled on a farm near Belleville, Illinois, where his education, classical and mathematical, was continued by parental instruction, aided by the part he took in the education of several younger brothers. At the age of eighteen he went to Philadelphia, and pursued the study of civil engineering under the advice of such eminent engineers as Roberts and Trautwine. His ardent desire for knowledge attracted the attention of Dr. Patterson, Prof. Bache, and other members of the Philosophical Society; and, soon after Prof. Bache took charge of the Coast Survey, he attached young Hilgard to the corps of assistants which he was about to form, and which, under his training, has attained so eminent a position as a scientific body. Hilgard was soon recognized as one of the leading spirits of the work, and by zeal in active service, untiring application, and the improvement wrought in all branches of the work that he touched, rose to the position of Chief of the Bureau of the Coast Survey at headquarters in Washington. To this position, which he holds at the present time, he was assigned at the beginning of the war of the rebellion, which called forth the best efforts of every member of the Coast Survey, and brought into play its resources of important information gathered during previous years.

Mr. Hilgard's scientific work has chiefly been in connection with his practical labors, consisting of researches and discussion of results in geodesy and terrestrial physics, and in perfecting methods and instrumental means connected with the same. The annual reports of the Coast Survey contain numerous papers from his hand on the application of the method of least squares to geodesy, on determinations of latitude, azimuth, and longitude; on methods of precision in measuring lengths, and on terrestrial magnetism. In 1872 he executed, in connection with the telegraphic determination of the longitude between America and Europe through the French cable, a similar de-

termination between the observatories at Paris and Greenwich, which supersedes the value previously admitted, correcting it by nearly half a second of time. His essay on "Tides and Tidal Action in Harbors," first published as a lecture before the American Institute, is remarkable for its lucid and terse exposition of principles without the aid of mathematical symbols. While possessing great facility in employing the aid of the higher mathematics, Mr. Hilgard systematically avoids, as far as practicable, their introduction in his writings, preferring to use logical statements of the processes of reasoning.

As part of the duties of his office, Mr. Hilgard has charge of the construction and verification of the standards of weight and measure for the United States, and, by order of Congress, has been for some years past engaged in preparing metrical standards of great precision for distribution to the several States. In this connection he was appointed a delegate to the International Metrical Commission, which met at Paris in 1872, having for its object the construction of new metrical prototypes of great precision and permanence, and which has since resulted in the establishment of an International Bureau of Weights and Measures at Paris, under the direction of a committee, of which Mr. Hilgard is a member. A valuable and instructive treatise on "Methods of Precision in measuring and weighing" was read by him before the Stevens Institute of Technology, but has not yet been published.

When, in 1863, the National Academy of Sciences was chartered by Congress, Mr. Hilgard was one of the original members named in the act. He is at present the home secretary of that scientific body. The compliment of honorary membership has been conferred upon him by the American Philosophical Society of Philadelphia, and the Academy of Arts and Sciences of Boston. His frequent communications to the Philosophical Society of Washington are evidence of a very active interest in scientific research, maintained notwithstanding the exactions of his arduous official labors. A work of great interest, which he is now conducting outside of his official sphere, is a magnetic survey of the United States, prosecuted at the expense of the Bache Fund, arising from a bequest of the late Alexander Dallas Bache to the National Academy of Sciences.

No small part of Mr. Hilgard's services to science and education is to be found in the readiness and obliging disposition with which he has constantly given information and rendered facilities by the loan of instruments and apparatus to persons engaged in scientific research or instruction. Besides meeting numerous requests of this kind at home, he has given his best aid and advice to the equipment of government surveys in the Sandwich Islands and in Japan. Although Mr. Hilgard's scientific work has been generally limited to the sphere embraced in his practical pursuits, he has been a very active student in other branches of science, especially dynamics and molecular physics.

EDITOR'S TABLE.

A SOCIAL EXPERIMENT.

WE observed, a while ago, the meeting of two gentlemen who, after salutation, broke at once into mutual and vehement expressions of disgust at the Beecher trial, and then sat down and discussed it for an hour. Such has been the general experience. Newspapers have bemoaned the necessity of publication, and then howled for the extension of the proceedings, meantime sending out their interviewers in all directions, to rake the gutters of scandal for further and filthier details. Similarly, by the mass of readers, the reports have been first deplored and then devoured to the last crumb. The protests were hollow concessions to decency; what followed revealed the actual and honest mental condition of the parties.

This aspect of the trial, as an index of public taste, is not without its instructiveness. It was evidently rich in elements that are appreciated by our people, and that take a deep hold of their feelings. It fed the craving for personal and prurient gossip, and, moreover, left something to bet on. It combined, in its various phases, the fascinations of the tea-party, the prize-ring, and the regatta. The lower education, by bringing the masses of the people up to the capacity of reading the newspapers, and the higher education, by allying itself with the horse-racing passion, have well prepared the community to enjoy the drama lately acted on Judge Neilson's stage. True, it was the old story of private suffering turned to public sport, but with what refinements in its modernized aspect! A dash of brutal bloodshed, a little gladiatorial human butchery, were indispensable to the perfection of a Roman holiday; but, in our higher Christian civilization, we get up a six-months' carnival of keen excitement by mangling a single reputation. It is certainly worth something to find out how our people can be best amused.

We are far from agreeing with those who have filled the land with lamentation over the unmitigated evils of the Beecher trial. It has undoubtedly had its mischievous influences, but these we believe will be transient and far outweighed by the public benefits that cannot fail to arise from it. It was, of course, most painful to Mr. Beecher—and he has our deepest sympathy—but no one better than he could afford to make the sacrifice needed to insure the permanent good of such a thorough-going social experiment as this trial and its preludes have furnished. The case is of peculiar interest as a problem of the forces acting in society. It is a great mistake to suppose that the Plymouth pastor was alone on trial. Action and reaction are equal and opposite in things social as well as in things physical. The strain took effect all round; and the triers have been on trial as well as the defendant. We know a great deal more about lawyers and the law than we did before; we understand better about judges and the judiciary than we did before; and we have conceptions of the jury and the jury-system which we had not before; while the result of the new knowledge is not by any means to raise our estimate of them. They have been brought to the bar of common-sense and the public judgment, and nothing has happened in the history of legal proceedings in this country that can compare with this case in exposing the weakness, the anomalies, and the vices of the system under which we live, called the perfection of reason, for the administration of justice. Nowhere in society are in-

congruity and absurdity so deeply intrenched as in law and law administration, while the acutest and most powerful of the professions forms the body-guard and bulwark of the system. But of this we are little disposed to complain. To conserve the good we must tolerate the concomitant evil; and there is neither intelligence, wisdom, nor honesty enough in the country to make a better system. If we are ever to get out of it, we must slowly grow out; and nothing will facilitate this more than such a shaking up and exposure of our judicial doings before the world as this remarkable trial has just effected.

But, aside from its personal issues, the case has chiefly interested us as a test of popular intelligence, and as affording an instructive illustration of the way people form opinions. The opinions of the multitude are commonly inherited or adopted; they are rarely "formed" by rational processes, and whenever the attempt to form them is made under proper circumstances, we get the best possible measure of mental capacity, integrity, and the efficacy of education. The Beecher case was well suited to be an ordeal of popular judgment. It was a fresh question, without precedents, and had to be accepted upon its merits. Then it was an open question, or early so regarded by the public, and so entertained by the court. Besides, it was a complex question, well fitted to task mental effort, and it dealt with human motives, conduct, and character, elements belonging to the common experience of mankind. The situation was thus favorable for fair and intelligent judgment; and yet, under these conditions, we get one of the most unexampled lessons as to how little of rationality there is in human thinking, and how little evidence has to do with the formation of popular convictions. Our concern is not here with the issue involved in the trial and which preceded it, but with the way the public approached and dealt with it.

We shall be helped by reference to a rudimentary bit of the science of mind. When men are called rational creatures, if it is meant that they have a capacity of reason by which they can arrive at the truth, the idea is correct; if it is meant that they are characteristically rational or controlled by reason, the idea is quite erroneous. Men are habitually creatures of emotion rather than of intellect. The emotions are the motors or driving forces of our nature; in a few they are guided and governed by the intellect; in the many they are lawless agencies, dominating the intellect and enslaving the rational nature. It is therefore of immensely greater importance to know how men feel than what they think; in fact, the last is generally the consequence of the first. That which lies beyond the reason and the will in the mental constitution, and gets vent continually under the pressure of sentiment, impulse, passion, love, hate, habit, and prejudice, is of immensely greater volume and moment than all that is said or done under the influence of intelligent volition. The perverting influence of passion is well known; but it is equally true that emotions of every kind and degree disturb the intellectual balance. Sympathies and antipathies, hates and admirations, blind the reason, distort the judgment, and reduce the mental experience to the grade of emotional automatism. Men carry on their mental intercourse in terms of reason, and delude themselves with the fancy that they are logical, when in fact they are only venting their preferences or dislikes, or giving excuses for their prepossessions, or exploding their inveterate prejudices.

Now, probably no man has appeared in this country who has stirred up so much adverse feeling of all kinds as Henry Ward Beecher. For twenty-five years he has been more heard and more read than any other person, and has stamped his personality deep in the national mind. From the first he has

taken up subjects of intense popular interest, and has treated them with such boldness and power as to command universal attention. His attitude, moreover, has been such as to provoke partisanship, and arouse antagonism. Independent in theology, free and easy in the pulpit, and often rough upon the churches, he has raised a great deal of religious animosity. A vehement reformer, he has amazed and irritated conservative people. Foremost and often fierce in politics, during a long period of intense political excitement, he has stirred up an enormous amount of political detestation. This disturbing influence has been felt to the remotest corners of the land, but of course it has been more palpable around home. To the general causes of repugnance have been added local causes in his own city that have operated with virulent intensity. He had many and ardent friends whose indiscriminate praises produced revulsion and disgust in many minds. Brother clergymen were gangrened with jealousy at his overshadowing influence, while their congregations were charged with sympathetic spite.

Now, this is a dangerous position for a man to hold in a community, as in any untoward circumstances it could be turned against him with fatal effect. If anybody had a motive or design to unroof Plymouth church, smash the pastor, and drive him out of Brooklyn, the facilities of assault were at hand. It was only necessary to fix upon Mr. Beecher a scandalous charge, and it was sure to spread like fire in straw. It was not at all necessary for purposes of public effect to establish the charge by valid evidence; it was only necessary to link certain ideas together to make a circumstantial picture of scandalous details, with Mr. Beecher as the central figure, and public feeling, consisting largely of dislike, hatred, prejudice, and jealousy, would cement the ideas together and give them all the force and effect of proof. And such is notoriously the way the case was carried. The picture was made by the Woodhulls; and, backed by no better evidence than the Woodhull character, it was at once believed by multitudes in the way they believe most other things. Of course, all those whose estimate of Mr. Beecher was indicated by such terms as "blatherskite," "nigger-worshiper," and "priestly hypocrite," accepted the charge on sight; but with thousands upon thousands of others there was from the first an unavowed half-belief palpably originating in unfavorable feeling. With the great mass of the community, indeed, the case was absolutely prejudged, the "statements" following the Woodhull presentation clinching and closing it, so that the six-months' trial was a mere superfluous appendage. As has been often and truly said, with any other man the case could probably never have got a foothold in a court of justice; but with Beecher the whole country was on fire with excitement, and was determined to have it out; and so, with the coöperation of the newspapers, and an accommodating court, the people have regaled themselves on putrescent gossip for half a year. The possibility of such a social experiment would not have been previously believed; but if it could occur it is better that it should occur, as thereby we become wholesomely, if painfully, instructed in the ways of that curious thing we call public opinion.

"*KNOX THE INCOMPARABLE.*"

In another part of this magazine, under the title of "A Popular Verdict," will be found the painful story of one of the remarkable characters of the past generation. The sketch is far too meagre to do justice either to the traits of the man or to the causes that conspired to darken the later portions of his life.

We first became acquainted with the genius of Dr. Robert Knox in 1852, through a work issued in that year, entitled "Great Artists and Great Anatomists: a Biographical and Philosophical Study." It was a small book, but unique and racy to a remarkable degree. Full of erudition, bold, sarcastic, witty, heterodox, and abounding in acute suggestions, it combined fresh biographical glimpses of such men as Cuvier, Geoffroy St.-Hilaire, Da Vinci, Angelo, and Raphael, with an original and philosophical treatment of the art, the literature, and the science of the epochs in which these great characters lived. The humor, freedom, and pungency of this little *brochure* induced us to look further into the writings of this author, and we found in "The Races of Men" a book rich in information, and written in the same vivid and fascinating style. The relations of anatomy to art was a favorite subject with Dr. Knox, and he contributed much toward its development. He published (also in 1852) "A Manual of Artistic Anatomy, for the Use of Sculptors, Painters, and Amateurs," with illustrations by Dr. Westmacott. This work contains a great deal of information, set forth in the author's peculiar style; and the third part of the volume gives an interesting analysis of beauty, a theory of the beautiful, and an exposition of the author's views on the objects and aims of art. The bias of the anatomist, however, is perceptible, as he is disinclined to recognize poetry, music, and the drama, as belonging to the fine arts, shows little favor to architecture, and holds that sculpture alone is entitled to the rank of high art. The most brilliant lecturer of his time in England, he applied, in 1841, for the vacant position of anatomical lecturer to the art-students of the Scottish Academy; but, though strongly backed, he failed as Sir Charles Bell had previously thrice failed in his application for the professorship of anatomy to the Royal Academy in London. Knox failed, though supereminently the man for the place, because an incompetent rival, Mr. James Miller, surgeon, offered his services gratuitously — a consideration which, with the canny Scotch, outweighed all others. Of course, Mr. Miller, at the end of the year, asked for his predecessor's salary, and, after due manipulation and management, obtained it. It was such miserable chicanery and trickiness in education by which "mediocrity gets intrenched and consolidated and founded on adamant," that roused the indignation of Dr. Knox, and led to those scathing denunciations of official and conventional stupidity that did so much to stir up animosity against him. He would call a spade a spade, which, in a state of society despotically ruled by etiquette, was an unpardonable sin.

We have referred to Dr. Knox's work on the "Races of Men," and probably the most powerful cause of that unpopularity that was turned so fatally against him in the hour of his calamity was his early and uncompromising advocacy of the most advanced views upon this subject. He was one of the eminent founders of the modern science of anthropology. Ethnological questions had been systematically entered upon before his time, but the core of the inquiry had hardly yet been reached.

The dissertation of Blumenbach "De Generis Humani Varietate Natura" (1775), was the first great treatise on the races of men, and formed the text-book of Cuvier, Lawrence, Pritchard, Nott and Gliddon, Latham, Waitz, Morton, Pickering, and others. Dr. Knox became an early and independent student of the great problem of the human races, and its comprehensive investigation was a controlling object of his life. He sought to give a new direction to the study of race. He aimed at a knowledge of man in his scientific completeness, geographical, historical, and physical, and as a foundation of such knowledge he wished to have a

record of his normal structures, osteology, and nervous system, with all the deviations, rudimentary, excessive, or abnormal, that methodical observation might furnish. He demanded that man shall be inductively studied throughout his whole nature; and he classified his history with the history of the organic world, as, by unity of organization, connected with all life, past, present, and to come. Dr. Knox took the ground, bold ground half a century ago, of the vast antiquity of man, and, though holding to the Cuvierean view of the immutability of species, he shrank from no opprobrium of beliefs denounced at that time as spurious science, immoral in their influence and destructive of religion. He defended these unpopular views with pungency and power, as was his wont, and as a matter of course called down upon himself the reproachful epithets of "infidel" and "atheist." Where sufficient mud is thrown, some of it is sure to stick. The doctor became obnoxious to the theologians, and was looked upon with dread by the people on account of his horrible opinions; and, when the occurrences took place which are described elsewhere in our pages, he became the ready victim of malignant aspersion. Nearly half a century has now passed since the Edinburgh excitements; "Knox the incomparable," as he was styled by his admiring students, has been years in his grave, and the time has at length come when justice should be done to his memory.

LITERARY NOTICES.

THE AËRIAL WORLD. A Popular Account of the Phenomena and Life of the Atmosphere. By G. HARTWIG, M. & P. D. New York: D. Appleton & Co., 1875. Price, $6.00.

As a compend of interesting and valuable information concerning the atmosphere and its phenomena, this book deserves favorable mention. The reading public is familiar with previous publications by Dr. Hartwig, in which he has succeeded in presenting the results of inquiry in several departments of science in a manner at once popular, entertaining, and instructive. It is quite evident that his success as a writer lies in the judicious selection and arrangement of facts and incidents in science rather than in original investigation; and that he is doing excellent service in this direction will be conceded by all acquainted with his books. The time seems to have not yet arrived when scientific knowledge is sought by the general reading public, unless it be made attractive by skillful manipulations.

The present volume is a popular exposition of the science of meteorology, without being a scientific treatise on that subject. The amount of information in it is immense, but it is classified with excellent judgment, and, so far as we have examined it, is accurate in its science. The style is easy, perspicuous, sometimes florid, but always appropriate and pleasing.

The chapters on "Clouds," "Colors of the Sky," "Aërial Navigation," "The St. Elmo's-Fire," "Snow," and some others, are brilliant with descriptive passages. Chapters relating to topics of especial scientific interest are those on "The Magnitude, Pressure, and Ingredients of the Atmosphere," "The Propagation of Sound through it," "Echoes," "Winds," "Fogs," "Dew," "Rain," "Thunder-storms," "Aërolites," etc.

The volume is handsomely illustrated with plates and woodcuts, and a meteorological map.

To the specialist in the science of meteorology, this work may be of comparatively little value. It is not designed for such, and the author modestly observes that his aim has been less ambitious, and that he will not consider his time ill-spent if the perusal of it awakens in the mind of the reader a keener interest in the pages of Nature.

ON BRITISH WILD-FLOWERS, CONSIDERED IN RELATION TO INSECTS. By Sir JOHN LUBBOCK, Bart., F. R. S. With numerous Illustrations. London: Macmillan & Co., 1875. Price, $1.50.

THIS is the seventh volume in "Nature Series," and is a product of a wonderfully

active, capacious, and fertile mind. Few men have accomplished what Sir John Lubbuck has in the departments of ethnology, zoölogy, entomology, and several other branches of science, and are, at the same time, eminent and successful as he is in financial and commercial enterprise.

The present little volume will be read with interest and profit; although, as the author modestly tells us, it is quite incomplete, the subject of it being yet in its infancy. That flowers and insects are intimately related has long been known, but the importance and extent of those relations were scarcely suspected until recent time. "It is our illustrious countryman, Mr. Darwin," the author observes, "who first brought into prominence the fact that the importance of insects to flowers consisted in their transferring the pollen, not merely from the stamens to the pistil, but from the stamens of one flower to the pistils of another. . . . While, then, from time immemorial we have known that flowers are of great importance to insects, it is only of late that we have realized how important, indeed how necessary, insects are to flowers."

These ideas are illustrated and enforced by a series of careful and ingenious observations conducted by the author, "chiefly with the view of encouraging in his children that love of natural history from which he has derived so much happiness."

The work is illustrated by 130 figures, has a glossary, and a copious index.

STATEMENT AND EXPOSITION OF CERTAIN HARMONIES OF THE SOLAR SYSTEM. By STEPHEN ALEXANDER, LL. D., Professor of Astronomy in the College of New Jersey. Smithsonian Contributions to Knowledge, No. 280. Washington, 1875.

THE laws of Kepler declare, with respect to any one planet, that it moves in an ellipse about the sun, which is at one focus of this ellipse, and that the radius-vector of this planet (the line joining it to the sun) sweeps over equal areas in equal times: with respect to any two planets, these laws declare that the squares of their times of revolution about the sun are proportional to the cubes of their mean distances. This last law, as Sir John Herschel has remarked, binds all the planets together and gives to their motions a family likeness.

Conversely, if we inquire what law of central force will cause two planets to obey the laws just quoted, we find that this central force must vary in intensity inversely as the square of the distance. Given Kepler's laws, we can arrive at this law of force: assuming this law of force, Kepler's laws are a consequence.

Now, if in the planetary system we inquire what are the further laws, if any, which the members each fulfill, we find that there are resemblances, analogies, harmonies, but no *exact* laws which govern the masses, densities, rotation-periods, distances, etc. The law of Titius (or Bode's law) gave numbers which approximated to the mean distances of the major planets, until Neptune was discovered, the mean distance of which was strikingly different from that which this rule would assign to it. "Kirkwood's Analogy," which gives the rotation-time of a planet when its time of revolution about the sun is known, likewise gives some striking coincidences, but our ignorance of the rotation-times of Mercury, Venus, Uranus, and Neptune, does not permit us to test it very closely.

It has long been a fascinating branch of inquiry to investigate the question of the existence of such laws, and several inquirers have worked assiduously at this question, in pretty much the same way in which Kepler worked at the discovery of his laws, i. e., by pure trial of various hypotheses. The volume before us contains the results of such work, and we propose to present, in brief, an analysis of these results. The volume opens with a statement of Kepler's laws, and with a table showing the values of the masses, mean distances, and densities which the author assumes as the bases of his discussion. We notice here, as elsewhere in the book, that such data are usually taken not from the original sources, but at second hand. With regard to the Masses as given by the author, we note that the mass of Neptune is *not* "the Poul-Kova deduction;" that the mass of Uranus should be credited to Struve; that Encke's mass of Mercury, which is adopted, is not of equal value with Le Verrier's, which has been published for many years.

In the second section the relations of the mean distances are considered: if of the distance of Neptune we take five-

ninths, and of the number thus obtained we again take five-ninths and so on, we thus form a geometrical series of numbers. Of the first eight of these numbers *four* express roughly the mean distances of Mars, Jupiter, Saturn, and Neptune (of course *this* distance is represented as it forms the starting-point of the process): *one* is roughly the distance of Mercury in *aphelion* (not its mean distance, which is the element of the problem, but its largest distance from the sun); *one* lies between Venus and the earth, *one* between Mars and Jupiter, and *one* between Uranus and Saturn, but much nearer Uranus. So far all is fact, and the candid observer arrived at this point might be supposed to say, With five-ninths as a ratio I can satisfy only *three* out of the *seven* conditions I seek to satisfy, and hence five-ninths is not the ratio I want. But at this point the author makes three assumptions: 1. The earth and Venus have the "characteristics of *half planets*." That is, one of them is on each side of one term of the author's utterly arbitrary geometrical series. 2. Uranus being on one side of another of these terms (although no planet is on the other side), it also will be considered as a "*half planet*." 3. Mercury has characteristics of a "*double planet*," because we are forced to consider it in its two positions, *aphelion* and *perihelion*, in order to make *it* agree with the above-mentioned arbitrary geometrical series. Now we have the basis for reducing these disorderly half, double, and missing planets, to something like order; for, putting nine-fifths (the reciprocal of $\frac{5}{9}$ths) equal to r, we have seen that the ratio r does very well for Mars, Jupiter, Saturn, and Neptune (*whole* planets); by trial we can see that $r\,\frac{3}{4}$ does well for the "*exterior half planets*" (those *beyond* the terms of the primary series), and also that $r\,\frac{1}{3}$ will serve for Venus, an "*interior half planet*," "the only existing example of its kind in the planetary system."

These are the principal conclusions of the first two sections of the work: with a given ratio $\frac{5}{9}$ths we have satisfied *three* terms out of *seven*, and to reduce the four remaining terms to order we have made *three* arbitrary assumptions. The author now proposes *as a test* to use the mean distance of the asteroid-ring between Mars and Jupiter according to his primitive series. The terms for Saturn, Jupiter, and Mars, are known, and that for the asteroids can be put in by a simple proportion. He finds by this process that the ratio r (=$\frac{5}{9}$ths) will satisfy the existing numbers better if we gradually decrease it as we go farther from the sun, and therefore this r, which at first was constant, is made variable, and the law of its variability is determined from four terms (Mars, Jupiter, Saturn, and asteroids) the value of one of which (the mean distance of the asteroid-ring) must long remain unknown; and in this way a "criterion" is set up. After this it is impossible to speak of this part of the book as a work of science; it is rather an exhibition of fancy. Tennyson has called the profession of the law "a multitude of single instances;" and, without passing the limits of decorum or truth, we may characterize the steps by which these final laws are reached in the same way. After all this adjustment of values, the mean distance of Uranus as represented by theory is in error by $\frac{1}{20}$ of its entire amount—a trifle of 7,000,000 miles. A foot-note here says, "Why, after all, Uranus seems to have, as it were, *fallen in* from his appropriate position, may be considered in another connection."

The satellite systems of Jupiter and Saturn are next considered, and similar laws are found to obtain; except that r, which for the planetary system was altered only into $r\,\frac{3}{4}$ and $r\,\frac{1}{3}$, here must become $r\,\frac{1}{2}$, $r\,\frac{6}{7}$, $r\,\frac{1}{4}$, $r\,\frac{5}{6}$, while for Uranus's satellites r becomes $r\,\frac{3}{4}$. Moreover, while in the planetary system r regularly *increased* from Neptune inward, in the system of Jupiter it *decreases* and in that of Saturn it is *constant*.

It seems hardly surprising that, with so much liberty of assumption, *any* set of conditions can be approximately fulfilled, and it is well to remember that, even if a much better fulfillment of these conditions could be made, it would not show that a physical law existed. This fallacy underlies the whole book.

Section 3 is devoted to "Theoretical Considerations," and here we will not follow the author, since what we have just examined is there assumed as fact.

The author's theory of the Zodiacal light is given at some length, and the book

closes with a "Summation of Coincidences" sixty-one in number, which are supposed to support the author's position. From what has been said it will be evident that we doubt the willingness of a cautious person to follow the author in his conclusions; and we must regret that the Smithsonian Institution has given this book the sanction of its high name as a "contribution to knowledge."

GEOLOGICAL SURVEY OF ALABAMA. Report of Progress for 1874. By EUGENE A. SMITH, Ph. D., State Geologist.

THIS Report is the first of a series promised, giving in detail the geology of the State, to be followed by a general summary, with maps, charts, and illustrations. The final report will comprise the physical geography, geology, and paleontology, economic geology, agricultural relations, botany, and zoölogy, and will inaugurate a new era in the industrial progress and development of that State.

In the present Report several counties are considered separately, giving their topography, geology, and mineral resources, with a chemical report, and appendix of altitudes, mining statistics, etc. The Report of Prof. Smith is excellent in matter and method.

CATALOGUE OF THE FISHES OF THE EAST COAST OF NORTH AMERICA. By THEODORE GILL, M. D., Ph. D.

THIS is one of the invaluable series of publications issued by the Smithsonian Institution, and is a revision of the catalogue prepared by the author in 1861. In that catalogue the number of species of fishes on our coast, from Greenland to Georgia, was given as 394, but accompanied by the remark that the number might be reduced by further observation. That has been done, and only 351 nominal species are enumerated in this catalogue, notwithstanding fifty species have been added since then.

Our vast extent of coast is divided in the catalogue into geographical areas, with boundaries more or less perfectly defined by the fauna characteristic of each. Thus the Arctic Fauna or realm is confined to the Arctic and Greenland seas. The next in order is called the Syrtensian Fauna, including the coasts of Labrador and Newfoundland. The Acadian Fauna extends thence to Cape Cod, but more southerly in deep water. The Virginian Fauna extends from Cape Cod to Cape Hatteras, and the Carolinian Fauna extends thence to the reefs of Florida.

Prof. Gill has done eminent service in recognizing the great public want of popular names to species of fishes. Throughout the catalogue popular or common names are appended to the scientific ones, and, in many cases, new names have been framed for species having no other distinctive ones. At the close of the catalogue is a very full bibliography of "East Coast Fishes," also an index to the catalogue of both scientific and popular names.

A MANUAL OF DIET IN HEALTH AND DISEASE. By THOMAS KING CHAMBERS, M. D., Oxon. 310 pages, 8vo. Philadelphia: Henry C. Lea, 1875. Price, $2.75.

THE aims of this hand-book are purely practical, and therefore it has not been encumbered by the addition of the chemical, botanical, and industrial learning which collects round every article interesting as an eatable. Space has been thus gained for a full discussion of many matters connecting food and drink with the daily current of social life, which the position of the author, as a practising physician, has led him to believe highly important to the present and future of our race. The book is divided into three parts. Part I., "General Dietetics," treats of "Theories of Dietetics;" "On the Choice of Food;" "On the Preparation of Food;" "On Digestion," and "Nutrition." Part II., "Special Dietetics of Health," treats of the "Regimen of Infancy and Motherhood;" "Childhood and Youth;" "Commercial Life;" "Literary and Professional Life;" "Noxious Trades;" "Athletic Training;" "Hints for Healthy Travelers;" "Effects of Climate;" "Starvation, Poverty, and Fasting;" "The Decline of Life;" and "Alcohol." Part III., "Dietetics in Sickness," comprises "Dietetics and Regimen of Acute Fevers;" "Dietetics and Regimen of Certain other Inflammatory States;" "Of Weak Digestion;" "Gout and Rheumatism;" "Gravel, Stone, Albuminuria, and Diabetes;" "Deficient Evacuation;" "Nerve

Disorders;" "Scrofula, Rickets, and Consumption;" "Disease of Heart and Arteries." It is written in the author's usual pointed style, and will prove serviceable alike to the profession and to people of common-sense.

ARCHÆOLOGICAL RESEARCHES IN KENTUCKY AND INDIANA, 1874. By F. W. PUTNAM.

THIS paper, which was read by Dr. Putnam before the Boston Society of Natural History, and printed in its proceedings, is a very interesting statement of what the author discovered in the mounds and caves of Kentucky and Indiana during the last season, also of early discoveries in the mammoth and other caves many years ago. He visited the spot in "Short Cave" where the famous "Mammoth Cave mummy" was found sixty years ago, and quotes a very full description of the mummy, written probably by Mr. Merriam, of Brooklyn, New York. The paper is an important contribution to archæological knowledge.

PRACTICAL GUIDE TO THE DETERMINATION OF MINERALS BY THE BLOW-PIPE. By Dr. C. W. C. FUCHS, Professor in the University of Heidelberg. Translated and edited by T. W. DANBY, F. G. S. London: Field & Tuer. Price, $2.50.

THE author informs us that the manuscript of this work has long been used by members of his own classes, and is now offered as an introduction to the determination of minerals by the blow-pipe process, and of crystallized specimens by their physical characteristics.

The work will be appreciated by students in the laboratory. It is of no value to the general reader.

DEVONIAN TRILOBITES AND MOLLUSKS OF ERRERÉ, Province of Pará, Brazil. By Profs. CH. FREDERICK HARTT and RICHARD RATHBUN.

THIS paper, reprinted from the "Annals of the Lyceum of Natural History," New York, shows that a close relationship exists between the Devonian fossils found in New York State, and especially in the Hamilton rocks, and those of Errerê, in Brazil, the geological horizon, and many of the forms of life, being almost identical. Aside from the general scientific interest of the paper, these facts render it especially valuable.

EIGHTH ANNUAL REPORT OF THE PEABODY MUSEUM OF AMERICAN ARCHÆOLOGY AND ETHNOLOGY. Presented to the President and Fellows of Harvard College. Cambridge, 1875.

THIS Report opens with appreciative recognition of the services of the late Prof. Jeffries Wyman, to whose industry and great abilities as an osteologist the successful organization of this museum is largely due. He was appointed curator at the first meeting of the Board of Trustees held after Mr. Peabody's "letter of gift," dated October 8, 1866, and in his first "Annual Report" stated that the collection consisted of about fifty specimens. The latest entries in the catalogue bring the numbers up to about 8,000.

The Report, which is illustrated, comprises the additions to the museum in 1874. Of these are varieties of jars, dishes, pots, drinking-cups, water-jugs, water-coolers, and statuettes, exceedingly curious and interesting. With ample resources and skillful management, the museum is a gratifying success.

PUBLICATIONS RECEIVED.

European Lighthouse Systems. By Major G. H. Elliot. New York: Van Nostrand. Pp. 284. Price, $5.

Notes on Building Construction. Philadelphia: Lippincott. Pp. 234.

Report of the Michigan State Board of Health. 1874. Pp. 221.

American State Universities and the University of Michigan. By Andrew Ten Brook. Cincinnati: Robert Clarke & Co. Pp. 418. Price, $3.50.

Algebraic Problems. By J. Ficklin, Ph. D. New York: Ivison, Blakeman, Taylor & Co. Pp. 192. Price, $1.50.

Religion and Science. By Charles W. Shields, D. D. New York: Scribner. Pp. 69. Price, $1.

What and How to Read. By G. A. F. Van Rhyn. New York: Appletons. Pp. 251.

Bacon *vs.* Shakespeare. By Thomas D. King. Montreal: Lovell Publishing Company. Pp. 187.

Startling Facts in Modern Spiritualism.

By N. B. Wolfe, M. D. Chicago: Religio-philosophical Publishing House. Pp. 570.

Missouri University Report, 1875. Pp. 210.

Report on the Mineralogy of Pennsylvania. By F. A. Genth. Pp. 206.

The Physiological Reasons why. By A. Hutchins, M. D. Brooklyn: W. W. Swayne. Pp. 50.

The Genera Geomys and Thomomys. By Dr. E. Coues. Pp. 73.

Bulletin of the Buffalo Society of Natural Science. Vol. II., No. 4.

Mineral Deposits in Essex County, Mass. By C. J. Brockway. Boston: A. Williams & Co. Pp. 60. Price, 50 cents.

Fishes of Indiana. By D. S. Jordan, M. D. Pp. 42.

Reasons for embracing the Doctrines of Swedenborg. By Rev. G. Bush. New York: E. H. Swinney. Pp. 120.

Transactions of the American Society of Civil Engineers. May, 1875. Pp. 140.

Bureau of Education. Nos. 3 and 4, 1875. Pp. 108.

Melanosiderite. By J. P. Cooke, Jr. Pp. 11.

The Sun and the Earth, by Balfour Stewart; Force, by J. W. Phelps. Boston: Estes & Lauriat. Pp. 31. Price, 25 cents.

Insects of the Field. By E. S. Packard, Jr. Boston: Estes & Lauriat. Pp. 31. Price, 25 cents.

MISCELLANY.

TO HERBERT SPENCER.

BY GRANT ALLEN.[1]

Deepest and mightiest of our later seers,
  Spencer, whose piercing glance descried afar
Down fathomless abysses of dead years
  The formless waste drift into sea or star,
And through vast wilds of elemental strife
Tracked out the first faint steps of yet unconscious life;

Thy hand has led us through the pathless maze,
  Chaotic sights and sounds that throng our brain,
Traced every strand along its tangled ways;
  And woven anew the many-colored skein;
Bound fact to fact in unrelenting laws,
And shown through minds and worlds the unity of cause.

Ere thou hadst read the universal plan,
  Our life was unto us a thing alone:
On this side Nature stood, on that side man,
  Irreconcilable, as twain, not one:
Thy voice first told us man was Nature's child,
And in one common law proclaimed them reconciled.

No partial system could suffice for thee,
  Whose eye has scanned the boundless realms of space;
Gazed, through the æons, on the fiery sea,
  And caught faint glimpses of that awful face,
Which, clad with earth, and heaven, and souls of men,
Veils its mysterious shape forever from our ken!

As tiny builders in some coral shoal,
  Raising the future mountain to the sky,
Build each his cell, unconscious of the whole,
  Live each his little life, and work and die;
Even so the lesser toilers in thy field
Build each the little pile his narrower range can yield.

But, like a skillful architect, thy mind
  Works up the rock those insect reasons frame,
With conscious plan and purpose clear defined
  In arch and column, toward a single aim,
Till, joining part to part, thy wider soul
Piles up a stately fane, a grand, consistent whole.

Not without honor is the prophet's name,
  Save with his country and his kin in time;
But after-years shall noise abroad thy fame
  Above all other fame in prose or rhyme;
For praise is his who builds for his own age,
But he who builds for time must look to time for wage.

Yet, though thy purer spirit do not need
  The vulgar guerdon of a brief renown,
Some little meed, at least, some little meed
  Our age may add to thy more lasting crown;
Accept an unknown singer's thanks for light
Cast on the dim abyss that bounds our little sight.

[1] Professor of Mental Philosophy in Queen's College, Jamaica.

Sleep and Digestion.—Speaking from his own experience, which would appear to differ from the experience of other people, Frank Buckland asserts that the best time to go to bed is immediately, or very soon, after the principal meal of the day. "All animals," he remarks, "always go to sleep, if they are not disturbed, after eating. This is especially noticeable in dogs; and the great John Hunter showed by an experiment that digestion goes on during sleep more than when an animal is awake and going about." Mr. Buckland finds a con-

firmation of his theory in the drowsiness which settles down on elderly men over their wine. "Nature says to them, 'Go to bed.' They will not go to bed, but still Nature will not allow her law to be broken, so she sends them to sleep sitting in their chairs." But, then, does not Nature quite as clearly indicate, by means of the nightmares and the unrest with which she torments the would-be sleeper who has gone to bed directly after a heavy meal, that a full stomach is not the best preparation for slumber? Many persons with whom this prescription for sleep would fail, may perhaps find another prescription given by Mr. Buckland more effectual, viz., eating onions, the essential oil of which possesses highly-soporific powers.

The Use of Paris-Green.—The use of Paris-green in dealing with the Colorado beetle has been condemned on the ground both that it poisons the soil, rendering it sterile, and that it is liable to be absorbed by the plant. Certain experiments made by Mr. McMurtrie, chemist of the Department of Agriculture, throw much light upon this question, and therefore are worthy of reproduction here. To determine the first point, that is, whether the Paris-green poisons the soil, Mr. McMurtrie planted peas in a number of flower-pots, each containing the same amount of earth, and all but one containing a certain proportion of Paris-green. The proportion of this substance varied from 100 milligrammes up to five grammes. The first five pots contained Paris-green as follows: No. 1, none; No. 2, 100 milligr.; No. 3, 200; No. 4, 300; No. 5, 400. In all of these the peas grew equally. In No. 6, containing 500 milligrammes, the plant was less vigorous than in No. 5. This, then, may be regarded as the proportion of Paris-green which impairs the fertility of soil. As the proportion increases, the plant grows feebler and feebler till No. 12 is reached, containing two grammes of Paris-green. Here the plant barely appears above the surface. In the rest of the pots, containing respectively three, four, and five grammes, the plant sends no shoot above the surface.

The proportion of 500 milligrammes in the flower-pot No. 6 is equal to 145.6 grammes per cubic foot, or 906.4 pounds per acre, calculating for a depth of one foot. Now, as less than two lbs. of Paris-green per acre is enough to use in warring against the beetle, it would take about 500 years to poison the soil, supposing the green to be applied every year, and that it was all retained. "But when rotation of crops is practised," says Mr. McMurtrie, "and application of the poison cannot therefore take place upon the same plot more than once in three or four years, it is probable that each application, being acted on by the natural solvents of the soil, will be removed by drainage before another is made." To the question whether arsenic can be absorbed and assimilated by the plant in the economy of growth, he replies in the negative. All of the plants grown, from the largest to the smallest, were examined according to Marsh's test for arsenic, but its presence could not be detected.

Periodicity of Thunder-storms.—W. von Bezold lately presented to the Munich Academy of Science a paper on the "Periodicity of Thunder-storms," basing his remarks upon a series of observations which extended over a period of 105 years prior to 1869. A synopsis of this paper we here reproduce from the *American Journal of Science*. He finds that in years when the temperature is high and the sun's surface relatively free from spots, thunder-storms are abundant. But as the maxima of the sun-spots coincide with the greatest intensity of auroral displays, it follows that both groups of phenomena, thunder-storms and auroras, to a certain extent supplement each other, so that years of frequent storms correspond to these auroras, and *vice versa*. He observes that such a connection between sun-spots and storms does not by any means sanction the supposition of a direct electrical interaction between the earth and the sun, but may be simply a consequence of a degree of insolation dependent upon the sun-spots.

These changes in the insolation, according to Köppen, manifest themselves in different latitudes not contemporaneously but successively. The phenomena of thunder-storms, on the other hand, do not depend alone upon the condition of the place in question with respect to temperature, but also on the condition of the atmosphere at

points far distant and belonging to another zone. This appears most distinctly in the storms which accompany electrical displays. The peculiar intermediate position which the weather curve takes between the curves of sun-spots and temperature may possibly find its explanation in this fact. Observations recently published in Saxony confirm these conclusions in a striking manner.

Volcanic Outbreaks in Iceland.—Since the beginning of the present year volcanic action has been almost incessant in Iceland. The following particulars of the outbreaks we find in *Nature:* In March the Dyngjufjöll was incessantly vomiting fire, and the eruption was steadily spreading over the wilderness. The farmers in the region around the My-vatn Mountains were obliged to remove in order to find pasture for their stock, the country being covered with ashes. Early in April a new eruption had broken out in a southeasterly direction from Barfell. A party went out from Laxardal to explore, and on approaching the place of eruption they found the fire rising up from three lava-craters. At a distance of 100 to 150 yards to the west from the craters a large fissure had formed itself as the fire broke out, and the land had sunk in to the depth of about 18 feet. Into the hollow thus formed the lava had poured at first, but now it flowed in a southwest direction from the two southern craters. The northernmost crater had the appearance of being oblong, about 600 yards in length, and from this crater the molten red-hot lava was thrown about 200 or 300 feet into the air in one compact column. The top of this column then assumed a palmated appearance, and the lava fell down in small particles, like drops from a jet of water, which, as they became separated from the column, grew gradually darker, and split into many pieces, bursting into lesser and lesser fragments as they cooled. No flames were observed, but the glare proceeded from these columns and the seething lava in the craters. At times the explorers could count twenty to thirty of these columns. No real smoke accompanied the eruption, but a bluish stream, which expanded and whitened in color as it rose to a greater distance from the crater; and such seemed to be the power of this blue jet of steam that it rose straight into the air for many thousand feet, despite a heavy wind blowing.

How we keep our Mouths shut.—Donders asserts that the mouth is kept closed, not by the action of the muscles connected with the lower jaw, but by atmospheric pressure. He has investigated this phenomenon experimentally. By employing a manometer, communicating with the space between the tongue and the hard palate, he finds, when the mouth is kept shut, a negative pressure corresponding to from two to four millimetres of the mercurial column. There are two suctorial spaces in the mouth: the principal one is bounded by the tongue below, the hard palate above, and the soft palate behind; the other is situated between the tongue and the floor of the mouth. The former is used in sucking liquid through a straw; the latter (sometimes) in smoking. Both are employed when we endeavor, with the mouth closed, to extract a foreign body from between the teeth. The mouth may be shut during sleep, when the muscles of mastication are relaxed. If a man fall asleep in the sitting posture with his mouth open, his jaw drops; the tongue not being in contact with the hard palate, the suctorial space is obliterated; the soft palate no longer adheres to the root of the tongue; and, if respiration be carried on through the mouth, the muscular curtain begins to vibrate, and snoring is the result.

Aliaskan and Aleutian Mummies.—The custom of preserving or mummifying the bodies of the dead, as formerly practised by the natives of the islands in Behring Sea, is accounted for very ingeniously by Mr. William H. Dall, in the *American Naturalist.* On the main-land, either on the Asiatic or the American side, the custom does not appear ever to have existed. In the Chukchee Peninsula, on the Asiatic side, there is no soil in which to bury the dead, and cremation is impossible from the want of wood; hence the natives expose their dead to the tender mercies of bears, dogs, and foxes. In the Yukon Valley, Alaska, the soil is frozen hard, and excavation is extremely difficult; but timber abounds,

and the bodies of the dead are boxed up in wooden coffins and elevated on four posts. On the islands the soil is not permanently frozen, and graves might be easily dug, but wood is scarce. Here the bodies might easily be buried, were it desirable. But, then, why *bury* the dead, if there are no wild animals to disturb the remains? The islands have no such animals, and hence the natives laid their dead away in nooks and crannies of the rocks.

Mr. Dall describes as follows the method adopted by the Kaniags and Alëuts in preserving dead bodies: First, an opening was made in the pelvic region, and the internal organs removed. The cavity was then filled with dry grass, and the body placed in running water. This in a short time removed most of the fatty portions, leaving only the skin, bones, and muscles. The knees were then brought up to the chin, and the whole body secured as compactly as possible by cords. The bones of the arms were sometimes broken to facilitate the process of compression. The remains were then dried. When thoroughly dried, the cords were removed, and the body usually wrapped in a shirt made of the skin of aquatic birds, with the feathers on; over this were wrapped pieces of matting, varying from coarse to exceedingly fine. Over this sometimes a water-proof material, made from the split intestines of the sea-lion, sewed together, was placed. Outside of this were usually the skins of the sea-otter, or other fur-animals, and the whole was secured in a case of seal-skins, coarse matting, or similar material, secured firmly by cords, and so arranged as to be capable of suspension.

Age of the Niagara Gorge.—It has for thirty years been the received opinion of geologists that the whole of the gorge of the Niagara, from Queenstown to the Falls, was excavated since the glacial period, and the work here done has been assumed to be a more or less accurate measure of the time elapsed since that period. But Mr. Thomas Belt, on a visit to Niagara last year, discovered what he takes to be sufficient evidence for asserting that the post-glacial gorge extends only from Queenstown up to the whirlpool, and that between the latter point and the Falls the Niagara flows in its preglacial bed. The author holds that the present river is cutting back the gorge much more slowly than Lyell estimated; that, instead of one foot yearly, the retrocession is not more than, if it is as much as, one foot in ten years; and that, allowing for the comparative softness of the rocks below the whirlpool, we must put back the occurrence of the glacial period to at least 200,000 years ago, supposing the entire gorge from Queenstown to the Falls to have been excavated since that time. "But if," says Mr. Belt, "the conclusion at which I have arrived is correct — that the gorge, from the whirlpool to the Falls, is preglacial, and that the present river has only cut through the softer beds between Queenstown and the whirlpool, and above the latter point merely cleared out the preglacial gorge in the harder rocks—then 20,000 years, or even less, is amply sufficient for the work done, and the occurrence of the glacial epoch, as so measured, will be brought within the shorter period that, from other considerations I have argued, has elapsed since it was at its height."

Have Animals a Sense of Humor?—A writer in *Nature*, George J. Romanes, brings together some instances tending to show the existence in some animals of a sense of humor. A young orang-outang in the London Zoölogical Gardens used frequently to amuse the spectators by inverting on her head her feeding-tin, and the animal was evidently gratified when her conduct called forth a laugh. A Skye terrier belonging to Mr. Romanes, "while lying upon one side and violently grinning, would hold one leg in his mouth." The animal was much pleased whenever this "joke" was duly appreciated, but would become sulky if no notice was taken of it. This dog was fond of catching flies upon the window-panes; but, if ridiculed when unsuccessful, he was evidently much annoyed. Having failed repeatedly on a certain occasion to catch a fly, he eventually became so distressed that "he positively *pretended* to catch the fly, going through all the appropriate actions with lips and tongue, and afterward rubbing the ground with his neck as if to kill the victim. So well," continues Mr. Romanes, "was the whole process simu-

lated, that I should have been quite deceived, had I not seen that the fly was still upon the window. Accordingly I drew his attention to this fact, as well as to the absence of any thing upon the floor; and, when he saw that his hypocrisy had been detected, he slunk away under some furniture, evidently very much ashamed of himself."

Mechanical Action of Light.—It has been supposed that the rays of light, as distinguished from heat-rays, can produce no mechanical effects, such as repulsion and attraction; and the circumstance that these rays are unable to propel the arms of a vane suspended *in vacuo* has even been employed as an argument against the truth of Newton's emission theory of light. Mr. William Crookes, however, at a recent meeting of the London Royal Society, exhibited an apparatus which he calls "the radiometer," by means of which he proves that the luminous rays produce direct mechanical effects, after all the thermic rays have been strained out. The radiometer is described as consisting of four pith disks, fixed at the extremities of two crossed arms of straw balanced on a pivot at the point where the straws cross each other, so that they can spin round on the pivot. These pith disks are white on one of their sides and blackened on the other. The entire arrangement is inclosed in a glass bulb, from which the air is removed by means of a Sprengel pump. On being subjected to the action of light from which ninety-five per cent. of the heating rays had been strained out by means of an interposed plate of alum, the disks rotated with a speed little inferior to that when the heat-rays were allowed to mingle with the rays of light. And what is very singular, it is the blackened surface which is repelled by the luminous rays. Inasmuch as light is reflected by a white surface, and absorbed by a black, one should expect that in the experiment the white faces of the disks would rather be repelled. This anomaly Mr. Crookes does not attempt to account for, and he is content to let the facts speak for themselves, being confident that in due time the laws governing them will be made manifest.

It having been suggested by Prof. Osborne Reynolds that the movement of the little vane might be due to evaporation and condensation on the surface of the pith disks, Mr. Crookes showed that this was not the case. He exhibited the very same effects with a lever-arm of platinum, suspended by an arm of platinum, the whole of which had been heated to redness again and again, during thirty-six hours of exhaustion by the Sprengel pump.

Prof. Huxley on the Amphioxus.—In a preliminary note upon the brain and skull of Amphioxus (the lancelet), Prof. Huxley shows that, although these organs are not fully differentiated in this animal, yet well-marked divisions of the nervous axis and spinal column exist which answer to the encephalon and cranium of the higher fishes. The homologies of the anterior pairs of nerves are worked out, and the skull is considered to be represented by the segments of the body which lie in front of the fifteenth, counting from before backward. The many points of resemblance in structure between the lancelet and the young form or larva of the lamprey (*petromyzon*) are insisted on, and it is suggested that Amphioxus should be regarded as the type of a new primary division of the class Pisces, to be called *Entomocrania*, as contrasted with all other known fishes, in which the primary cranial segmentation is lost, and for which the term *Holocrania* is proposed.

What Savages think of Twins.—In Africa, according to Dr. Robert Brown ("Races of Mankind"), the birth of twins is commonly regarded as an evil omen. No one, except the twins themselves and their nearest relatives, is allowed to enter the hut in which they first saw the light. The children are not allowed to play with other children, and even the utensils of the hut are not permitted to be used by any one else. The mother is not allowed to talk to any one not belonging to her own family. If the children both live till the end of the sixth year, it is supposed that Nature has accommodated herself to their existence, and they are thenceforth admitted to association with their fellows. Nor is this abomination of twin births restricted to

Africa. In the island of Bali, near Java, a woman who is so unfortunate as to bear twins is obliged, along with her husband, to live for a month at the sea-shore or among the tombs, until she is purified. The Khasias of Hindostan consider that to have twins assimilates the mother to the lower animals, and one of them is frequently put to death. An exactly similar belief prevails among some of the native tribes of Vancouver Island. Among the Ainos, one of the twins is always killed, and in Arebo, in Guinea, both the twins and the mother are put to death.

Father Secchi on Solar Spots.—In summing up the results of his observations on solar prominences and spots from April, 1871, the Roman astronomer, Father Secchi, states that since that date there has been a very marked diminution both in the number of groups of sun-spots and in their area—a result of the eleven-year period, the maximum having occurred about 1871. But he has observed the same diminution in the number of prominences: in 1871 the daily average was about fifteen, while now it is six or seven. In the same period the number of groups of sun-spots in each rotation has decreased from about twenty-five to eight, and the mean area has diminished to about one-fifth. Further, the prominences are now very rare near the poles. Secchi further remarks on the discordance between his results of 1852, showing a difference of temperature between the solar equator and poles, and those of Prof. Langley, and infers that there has been a change in the sun in this respect, consequent on the decrease of solar activity. He objects to Langley's method of moving his thermopile to different parts of the image instead of moving the telescope so as to bring the points of the image in succession on the thermopile, and thus to avoid differences of inclination to the axis of the lenses.

Prof. Loomis on the Storms of the United States.—This eminent meteorologist presents, in the July number of the *American Journal of Science*, his third paper on storms, founded on the weather-maps of the Signal-Service. He is now able to confirm what was stated in his previous papers in regard to the general progress, direction, and barometric phenomena of storms in the United States. These papers of Prof. Loomis are admirable in method, and of very great value. The general direction of the storms which traverse the United States is found to be a little north of east, but varies somewhat with the seasons. Thus, July storms are most southerly in their direction, being a little south of east, those of February being most northerly. Rarely, storms move for a time northward or southward.

By direction of a storm is meant the movement over the country of the whole storm, not the direction of the winds, and its progress varies greatly in rapidity. The average velocity during the past three years has been 26 miles per hour, the storms of August being slowest, those of February and March being most rapid. The storm of February 22, 1874, moved at the tremendous rate of 53.3 miles an hour, or 1,280 miles in a day.

It is also shown that the progress of storms is not uniform throughout the day, but has a uniform daily variation. The velocity is greater by 25 per cent. from 4.35 P. M. to 11 P. M. than during other portions of the day, and this is constant during each month of the year. The greatest velocity occurs at about 7 P. M. without apparent relation to the wind's velocity, or absolute temperature. "But," the professor observes, "it is the time when the temperature of the day is declining most rapidly." Now, this change of temperature has direct relation to those conditions which cause precipitation and extend the rain-area. By reference to a former paper of Prof. Loomis it will be seen that condensation in front of the storm-centre is one means by which a storm progresses. It is continually making up in its front where the air is vapor-laden, not in its rear where the air has been deprived of its vapor.

It will hardly admit of question that the velocity of a storm's forward motion is usually accompanied by an extension of the rain area in the direction in which the storm progresses. The average extent of this area in front of the storm-centre during three years is found to be 542 miles. Now, if this be increased 100 miles, the velocity

of the storm is also increased, and the reverse occurs when the area is diminished.

The general outline of a storm-area is an oval, the longest diameter of which is in direction of the storm's progress.

Around the centre of a storm are points or lines of equal barometric pressure, and the lines thus formed are called isobaric curves. These are, in shape, irregular oval, and the longer diameter may be, or may not be, in the direction of the storm's longer axis. The prevalent direction is a little north of northeast.

Prof. Loomis suggested in a former paper that intense and sudden cold arises from vertical movement or displacement of air, by which the warm air suddenly, in some cases almost instantly, rises, the cold air of the upper atmosphere displacing it by its descent. This conclusion is confirmed by recent observations. On the 15th of January, 1875, the thermometer at Denver indicated a fall of temperature of 48° in one hour, and, in another instance cited, the change was 36° in five minutes! It is significant that these sudden invasions of cold air appear first, as a rule, on the Rocky Mountains, or contiguous highlands. The presence of mountains seems to favor the development of cold, which would not be the case if the movement of the cold wave was an horizontal one from the arctic regions, as formerly supposed.

Experiments on the Sense of Taste.—In a communication to the London Physical Society on subjective sensations of taste, Dr. Stone called attention to two simple experiments, the first of which consists in applying a strong dilution of nitric acid to the root of the tongue by sucking it through a fine glass tube. If pure water be swallowed immediately after this, a sweet taste is produced. The author compared this effect to the complementary images seen in the eye after gazing at a powerfully illuminated body. He then adverted to the taste of the galvanic current. In the well-known experiment with pieces of zinc and silver, the zinc is actually dissolved in the saliva. But if one pole of a strong battery (ten Grove's cells in this case) be applied to the nape of the neck, and the other brought to the forehead, besides the flash of light, a strong taste is experienced of a metallic character. It disappears on breaking contact; and for this reason, as well as from the fact that the tongue is not in the direct line of circuit, and also that there is no substance in the saliva likely by decomposition to cause metallic deposition, it could hardly be referred to chemical action, but must result from direct stimulation of the sensory apparatus. Dr. Stone thought that a glimpse might thus be obtained of some correlation between the *modus operandi* of hearing and sight and that of taste. In the first case, a supplementary and automatic sensation, in the second the effect of a metallic solution, both entirely subjective, were excited without the presence of any sapid substance. The explanation may be that both classes of phenomena are due to molecular motion.

Do "Thorough-breds" revert?—The saying is a common one that domesticated animals tend continually to revert to the original or wild type, and do so revert if domesticating influences are withdrawn. At the Hartford meeting of the American Association for the Advancement of Science, W. H. Brewer, Professor of Agriculture in Yale Scientific School, called attention to this subject. He cites remarks made by an eminent scientist at a previous meeting as follows: "The hog has been greatly changed by domestication, and yet when left to himself he soon returns to the original type. During the late war *some of the most improved breeds* were turned loose and left to shift for themselves. *Three years after I found them possessing all the physical characters of the wild-boar of Europe.* He also stated that a similar fact had been observed with Durham cattle.

This statement, and all similar ones, Prof. Brewer sharply challenges. He refers to the confidence which owners and breeders of "thorough-breds" have in the permanence of acquired qualities; and says he has failed to find a single instance of reversion, nor has he found any one who knows of its having taken place. He suggests that the dogma (reversion) is used as an argument to sustain a certain scientific hypothesis. In order to ascertain the facts, Prof. Brewer has issued a circular containing the

following inquiries, and promises to give the results obtained at some future meeting of the association:

"1. Have you personally ever known any case where *thorough-bred* short-horn cattle, because of climate, poor feed, neglect, or any other cause, have become in character any thing else than short-horns—in other words, *where from any cause thorough-bred short-horns have degenerated into animals of any other breed or type?*

"2. Do you personally know of *thorough-bred* animals of any other breeds so changing or reverting?

"3. Have you ever heard of such a thing taking place, in the experience of other breeders, so well authenticated that you believe it to be a fact?"

The professor concludes his circular with the following remarks: "That *grade* animals often 'revert,' that curious freaks and 'sports' often attend violent crossing (and also that breeds *deteriorate* under bad management or bad conditions), are well enough known, but these facts do not affect the specific questions asked where *the blood is supposed to be kept strictly pure.*"

Laborers' Homes.—Dr. Stephen Smith, in an address to the New York Public Health and Dwelling Reform Associations, points out various methods of improving the homes of the laboring classes in this city. He holds that every family almost may own a house for itself, and instances the city of Philadelphia, where tenement-houses are unknown, and where the day-laborer may, and does, occupy a house which is, or is in process of becoming, his own property. In the city of New York, south of the Harlem River, it is impossible for the poor to build houses, unless there be such a reconstruction of the land as will diminish the cost of individual lots, and allow of a larger number of single houses to the acre. Dr. Smith favors the plan of single rows of dwellings fronting at both extremities upon streets. Blocks thus laid out would have no inclosed courts, the dwellings would be flushed with free currents of air on both sides, and a much larger number of people could be accommodated in the same area.

The system of building associations, such as exist in Philadelphia, is highly commended by Dr. Smith. The relation of the laborer to the building association is thus stated: "He borrows $1,000 in cash, agreeing to pay $1,200 and the interest; he stands charged with $1,200, paying $60 per annum: it would take twenty years to pay up $1,200. But at the end of the time, his share being worth $1,200, he stops paying, and the house is his own. In fact, however, he is a participant in the profits, the premium and the interest he pays going to reimburse himself, and it only takes in practice ten or twelve years to put him in absolute possession of his home." Dr. Smith's address is worthy the attention of all classes; it is published in full in the *Sanitarian* for July.

In London, too, there exist various associations whose object is to provide improved dwellings for the laboring classes. At the present time these associations own 7,558 improved dwellings, capable of containing a population of 36,078. The buildings have been erected at a cost of about $6,000,000, and the enterprise is an undoubted financial success. But regarded from the sanitary and moral point of view the results are still more satisfactory. That the moral well-being of the inhabitants is promoted by the enlarged provision made in the model lodging-houses for the decencies of life is self-evident. The sanitary advantages possessed by these dwellings will be seen from a comparison of their death-rate with the death-rate of England in general, of London, or of any district of London. "There is not one year," says the *Sanitary Record*, "in which the death-rate prevailing in the model lodging-houses is not much lower than in England, and in the country, city, and town districts with which it is brought into comparison. Take, for instance, the healthy year 1868; it shows a death-rate in the model lodging-houses of 15 per 1,000, the most favorable figure for any mixed population of male and female being 22—a difference of 7 per 1,000 in favor of the model dwellings." It is a very significant fact that whereas in 1874 the death-rate of children under ten in the general population of London was 48 per 1,000, in the lodging-houses it was only 24 per 1,000. And the saving of disease must be in the like proportion. But yet in these dwellings the population is

very dense, at least four times as dense as in the most thickly-peopled districts of London. Thus in the most populous district of the metropolis (Westminster) the population is 235 persons to the acre, while in the dwellings provided by the Metropolitan Association, including the large court-yards and gardens, the average is 1,140 to the acre: in one instance is is even as high as 1,620 to the acre.

Rate of Growths of Corals.—It is stated by Prof. Joseph Le Conte, in the *American Journal of Science*, for July, that the well-known branching or tree-coral (*Madrepora cervicornis*) increases in the length of its branches by growth about 3½ inches in a year. He came to this conclusion in the following manner:

At the Tortugas he found the prongs of this coral very near the surface, and all with their extremities at nearly the same level. All the prongs were dead for about the last three inches of their length, the lower limit of death appearing to be a perfectly horizontal plane. He ascertained that hundreds of acres were thus clipped, having the appearance of a clipped hedge, and he traced this result directly to a change of level of the ocean during each year. This change is about ten inches at Key West, owing to prevalent winds, the highest level being in September, the lowest in January. It is obvious that the branches of coral shoot upward with rise of water, and when near its greatest fall the new growth is destroyed. Lower down the corals are sufficiently beneath the surface to remain uninjured by the surface changes. The amount of dead coral indicates the growth, which is three inches for the growing period, or about 3½ inches for the entire year for the madrepore-stems in this region.

Methods of Physical Culture.—At a meeting of the alumni of Amherst College, Dr. Nathan Allen made some remarks upon physical culture, showing that by right it must form an essential part of a college curriculum. He instituted a comparison between boating and ball-playing on the one hand and gymnastics on the other, and said that while the former are calculated to awaken public interest on the subject of physical culture, and to improve the physical condition of great numbers, yet as a means *of health* they are not the best adapted for the scholar. They call into exercise chiefly certain muscles of the chest, the spine and the limbs, and when long continued produce an abnormal development of these particular muscles at the expense of other muscles. But health rather depends upon an harmonious development of the whole body. Then, too, the exercises of boating and ball-playing become at times so violent and protracted as to cause congestion in the vital organs, resulting in serious diseases and endangering life. Furthermore, these exercises can be carried on only by a few individuals, in pleasant weather and at particular seasons—circumstances which render them unsuitable to the student.

With gymnastics it is very different. These can be carried on daily and systematically by all, with little loss of time or risk of injury to person or to good morals. They can be so varied as to call into exercise every muscle of the body, and, if need be, strengthen the weak parts and repress those in excess. While they are calculated to improve the general health, by producing a well-balanced organization, they aim to bring all the physical forces of the system into the most favorable condition for study and mental improvement. They tend to bring about the greatest possible harmony of action in every part, especially between the physical and mental, so that the machinery of body and mind shall work to the best advantage.

Distribution of Ferns in the South Pacific Islands.—M. Eugène Fournier, from a study of the 259 species of ferns native to New Caledonia, whereof 86 are special to that region, and the rest common to it and other groups of islands in the Pacific and Indian Oceans, has been led to the conclusion that at one time New Caledonia and New Holland, as well as New Zealand, were united by means of Norfolk Island and other submerged islands. This hypothesis, he says, will explain the simultaneous presence, in countries with different climates at the present day, of species belonging to homogeneous groups, which the currents would not have been able to transport in

preference to others, and which, living in interior mountainous regions, are less exposed than littoral species to be drawn off by extraneous agents. As to the Mauritian Islands, it is very difficult to explain, by the fact of transport, the singular affinities connecting their flora with that of the oceanic isles. To suppose some lands to have disappeared between Madagascar and Australia is a bold hypothesis which will, perhaps, impose itself one day on science—above all, after the results attained by geologists, and recently expressed according to the special studies of Alphonse Milne-Edwards.

The Prairie Gopher.—Among the burrowing species belonging to the squirrel family, the prairie gopher (*Spermophilus Richardsoni*) holds prominent rank. Though one of the most abundant animals in our country, infesting hundreds of thousands of square miles of territory, almost to the exclusion of other mammalian forms, the prairie gopher has but lately received the honor of an adequate description. This service has been rendered by Dr. Elliott Coues in the pages of the *American Naturalist*. The habitat of the prairie gopher appears to extend from the Red River of the North to the Rocky Mountains, and from latitude 38° to 55°. So numerous are they in Dakota and Montana that, according to Dr. Coues, should certain portions of these Territories ever be settled, the little gophers will contend with the husbandman for the land more persistently and successfully than the Indians can hope to. The animal seems to be a modification of the chipmunk; in the language of Dr. Coues, "If we take a chipmunk and crop its ears down close, cut off about a third of its tail, give it a blunter muzzle, and make a little alteration in its fore feet so that it could dig better," we have a pretty good prairie gopher. The holes they dig are small, but many of them, like the burrows of the badgers, foxes, and prairie wolves, will admit a horse's hoof. In some regions so numerous are these holes that it is impossible to gallop a hundred yards except at the risk of life or limb.

It is not easy to determine what particular kind of ground the gophers most affect. "Passing over a sterile, cactus-ridden, alkali-laden waste," says Dr. Coues, "there would be so many that I would say, 'This suits them best;' in camp that very night, in some low grassy spot near water, there they would be, plentiful as ever." If the animals have any preference, it is a choice of the lighter and more easily-worked soils; and they seem to haunt especially the slight knolls of the prairie a few feet above the general level. One gopher to a hole is the universal rule, nor has the author ever seen any signs of a burrow being occupied by a pair.

The female brings forth in June, but the young are never seen outside of the burrow till July, when they are about two-thirds grown. The number of young produced at a birth is supposed to be about eight.

Dr. Coues is of the opinion that the gopher is torpid during most of the winter. The animal hoards up food, it is true, but not in sufficient quantity to suffice for so active a creature during an entire winter. The author has often watched them, where the grass was taller than usual, gathering their store. They rise straight up on their haunches, seize the grass-top, and bite it off; then settling down with a peculiar jerk, they sit with arched back, and stow away the provender in their pouches, with the aid of their fore-paws. Their cheek-pouches, both together, would hardly hold a heaping teaspoonful. Though properly a vegetarian, the gopher derives no small share of his summer food from carcasses of buffalo.

Recovery from Lightning-Stroke.—In his valuable work on "The Maintenance of Health," Dr. Fothergill has the following on resuscitation after lightning-stroke: "Persons struck by lightning are not always dead when they appear to be so. There are few recoveries from this state, because no means are tried to restore the sufferer. In the tropics there are many instances of persons, struck down by lightning, recovering after a heavy thunder-shower; and it would appear that cold affusion to the body has a decided action in such cases. The injured cannot be harmed by the free use of cold water, and if only an occasional recovery took place it would be well worth the pains bestowed. The persons so injured should have cold water poured or even dashed freely over them."

The Air-Bladder of Fishes.—While engaged in measuring a degree of the meridian in 1806, the eminent physicist and astronomer Biot accidentally made the discovery that fishes living at great depths have the air-bladder filled with almost pure oxygen. Another French scientist, Dr. Moreau, has recently confirmed and extended this observation of Biot's. According to Moreau, the air-bladder secretes pure oxygen, and the presence of other gases is due to other causes besides the secretion of the organ. To prove this point, he examined fishes which had for a considerable time lived in very shallow water, and found, from several analyses, that the average amount of oxygen in the air of their swimming-bladders was about sixteen per cent. He then plunged the fishes in water to the depth of about twenty-five feet, and found that the quantity of gas in the air-bladder was increased. The oxygen was now from forty-five to fifty-two per cent.

New Fossil Ungulates from Mexico.—In a communication to the Philadelphia Academy of Natural Sciences, Prof. Cope describes some new fossil Ungulata found by himself while employed in the Wheeler Topographical and Geological Survey of New Mexico. One of these fossil ungulates, *Pliauchenia Humphreysiana* (a new genus and species), is regarded as representing a genus of *Camelidæ* intermediary between *Procamelus occidentalis* and *Auchenia*. *P. Humphreysiana* was of about the same size as the former of these two animals, or somewhat larger than any of the existing llamas. Another new species of this same genus is *Pliauchenia vulcanorum*, represented in Prof. Cope's collection by the left maxillary bone, which proves it to have been a camel of about the size of the existing dromedary, and considerably larger than the preceding species. The typical specimen was found near Pojuaque, a village of the Pueblo Indians. Various bones of camels of the size of *P. vulcanorum* were also found, some of which doubtless belong to the same species. Of *Hippotherium calamarium*, a new species of three-toed horse, the oral and palatine parts of the skull, with the superior dental series of both sides, were found near San Ildefonso. Dr. Cope points out the specific differences between this animal and Leidy's *H. occidentale*, *H. speciosum*, and *H. gratum*. *Aphelops jemezanus*, a new species of fossil rhinoceros, is represented by a right mandibular ramus, found near the town of Santa Clara, on the west side of the Rio Grande.

Parental Instinct in Fishes.—The Trinidad perch does not stand all alone among the finny tribes in caring for the safety of its young. A correspondent, after reading the article "A Motherly Fish," on page 126 of the present volume, writes us as follows: "I think it is known to our fishermen that the catfish watches over its young. For the fact that it does I can vouch. A friend whose place of business was on the quiet wharf of Havre de Grace, Maryland, had an opportunity, during more than a week and several times each day, of observing the parental care of this fish. There were always two fishes with the brood. When approached, one of these would dart off, while the other, naturally supposed to be the mother, could be seen to flap her tail against the bottom till a cloud of mud was raised, concealing herself and her little ones. When the observer remained perfectly still for some time, the water becoming clear again, the mother could be seen hovering over a dark mass of moving small-fry a foot or more in diameter, while a little way off the other fish would be in attendance."

Mouthless Fishes.—Prof. Leidy lately exhibited at the Philadelphia Academy of Sciences an apparently mouthless fish, found in the Ouachita River, Arkansas. The fish is the buffalo sucker (*Catastomus bubalus*), an inhabitant of the Mississippi and its tributaries. The specimen is fifteen inches long. The maxillaries, premaxillaries, and mandible, are absent, and the integument is tightly extended between the end of the snout, the suborbitals, and the articular ends of the quadrates. In the centre of this expansion of the skin there is a small oval aperture one-fourth of an inch fore and aft, and one-eighth of an inch in transverse diameter. The hole is sufficient to admit a current of water for the purposes of respiration; but it is difficult to understand how the fish had procured its food. The cyprinoids generally are remarkable for

their small, toothless mouth, but it is nevertheless important in its prehensile capacity. The condition of the specimen is of course a deformity, but appears to be the result of a want of development of the jaws, and not of accidental violence. Such fishes are often caught in the Ouachita, and occasionally even they have been reported without a vestige of an oral orifice. If the latter condition really occurs, the fish can only supply itself with food and with water for respiration through the branchial fissures, by the alternating outward and inward movements of the opercula.

Hatching Frogs under Colored Glass.—In an experiment made by M. Thury, the eggs of *Rana temporaria*, a species of frog, were placed under identical favorable conditions, with the exception that some of the eggs received light through colorless glass, and others through green glass. The former developed rapidly, and by the end of May had a length of over one and a half inch, and well-developed hind-legs in most of them; the others were slowly developed, blackish in color, hardly had a length of three-quarters of an inch by the end of May, and were without a trace of hind-legs. By the 10th of June the former had their fore-legs, and some were changed to frogs; the others, still black, had no trace of legs, and breathed almost exclusively by means of their gills. By the 15th of July the one lot had become frogs; the others still had no legs, and by the 2d of August they were all dead, without a trace of legs having appeared. Some of the young of this lot, transferred to the vessel in which were contained the developed frogs, finished their metamorphosis.

Equine Idiocy.—A plant known in California as "rattle-weed" is said to produce in animals which eat of it symptoms much resembling those of amentia and frenzy. A correspondent of a San Francisco newspaper, writing from Monterey County, describes as follows the effect produced by this plant on a herd of fifty horses on a ranche in the southern part of that county: "They became," he says, "crazy, forsook the farm, and wandered off one by one over the plain, paying no attention to their mates or any thing else. They were too muddled in their brains to seek for water, and most of them died of thirst. Although they were wild, and had never been handled, any person could walk up to them on the plain and hit them with his hand, when they would jump, perhaps, straight up in the air, perhaps some other way, and act as though they were trying to leap a fence at every step. They seemed to retain their sight, yet would not turn aside for any thing. The poor demented beasts would walk over a precipice without the slightest fear or hesitation."

NOTES.

THE Cincinnati Industrial Exposition of the present year includes a Department of Natural History and Antiquities, and prizes are offered for the best collections in geology, and mineralogy, conchology, zoölogy, botany, numismatology, and archæology. The managers promise that the greatest care will be taken of all specimens sent in for exhibition. The prizes consist of silver and bronze medals.

A NOVEL form of snow-spectacles has been devised for the use of the British arctic expedition. These spectacles have neither glass nor iron in their composition; they are made of ebonite, and tied on the head by a velvet cord. They somewhat resemble two half walnut-shells fastened over the eye, and the wearer sees through a simple slit in front of the pupil. To give the wearer a side view, the sides of the eye-box are perforated with minute holes. These spectacles are said to be of great service in reading by lamp or gas light.

THE Royal Agricultural Society of England has the most numerous membership of any similar association in the world. It has on its roll 5,846 names. Its "Transactions" are published in half-yearly volumes.

THE *Phylloxera vastatrix* has made its appearance in England. At a meeting of the London Entomological Society, Mr. McLachlan exhibited a portion of a vine-leaf on which were the galls of *Phylloxera*. The leaf had been plucked in a greenhouse near London.

BEAN'S pneumatic-electric apparatus for lighting and extinguishing street-lamps is now in practical operation in a large part of the business portion of Providence, Rhode Island. The principle of this apparatus consists in a combination of compressed and rarefied air to open and close gas-cocks, and an electro-galvanic current, affording a spark to light the gas. It enables a single

operator at will to light or extinguish all the street-lamps of a city.

THE "Khedival" Geographical Society of Cairo lately held its first meeting under the presidency of Dr. Schweinfurth. The Khedive gives to the society a local habitation, suitably furnished, and also subscribes 10,000 francs a year to its funds.

THREE soldiers were simultaneously struck by lightning at the Satory Barracks, Paris, May 15th. In two of them the lightning produced complete relaxation of the muscles, and in the third muscular contraction. The latter, unlike the former, retained consciousness throughout. All recovered in a few days. The metallic buttons on their clothing were not affected by the electric current.

THE silver-mining region of Massachusetts, we are informed by a writer in the *Engineering and Mining Journal*, appears to extend from Gloucester, Massachusetts, on the south, to Portsmouth, New Hampshire on the north, and from the Atlantic on the east to North Andover, Massachusetts, on the west. The first discovered and thus far most prominent lode is the "Chipman," at Newburyport, which has been traced some three miles. The ore of this lode is chiefly galena, carrying from 50 to 150 ounces of silver to the ton. The average thickness of vein-rock on the Chipman lode is about 60 feet.

A MILL has been erected on the line of the Los Angeles & Independence Railroad, California, for the purpose of manufacturing the fibre of the cactus into paper-pulp. The experiment has been tried, says the *Scientific Press*, and an excellent quality of paper is the result.

THE managers of the great aquarium at Brighton, England, were very heavily fined a month or two since for keeping open on Sunday. A religious fanatic brought to the notice of the courts the violation, by the directors of the Aquarium, of an obsolete statute "for preventing the abuse and profanation of the Lord's Day." In the mean time publicans are allowed to keep their places open on the "Lord's Day."

IN the *American Journal of Sciences* for May, Prof. James D. Dana examines the evidences of the contemporaneity of man and the mastodon in Missouri, as presented in various pamphlets issued by Albert Koch, of St. Louis. Prof. Dana shows conclusively that Koch's "evidences" are worthless.

IN consequence of the excessive cold of the past winter, the deaths registered in the eight principal towns of Scotland in December amounted to 3,906, or, taking into account the increase of population, 1,000 in excess of the preceding month, and nearly 700 more than in any month since 1855, when registration of deaths commenced. The mortality in France from the same cause was equally great.

FAYETTE COUNTY, Tennessee, is said, in the Report of the Department of Agriculture, to have suffered a very great loss of mules and horses last spring by the buffalo-gnat. The best remedy against these pests is to put the stock at once in a dark stable, to be kept filled with smoke. "Death," says the report, "doubtless is partly caused by loss of blood, but mainly by poisoning the circulation."

IN our sixth volume, p. 743, Dr. Abbott confirms Wilson's statement as to the outside lichen covering of the yellow-bird's nest. A correspondent, writing from Southern Minnesota, confirms Brewer's statement, viz., that this bird covers the outside of its nest with fine vegetable fibres. The fibre commonly used is hemp. The yellow-bird thus appears to construct its nest differently in the West from what it does in the East. As for the eggs, our correspondent says that all he has ever seen have been marked with brown splotches on the large end, and he has some specimens which are thickly spotted over the entire surface.

THE annual death-rate of various cities in the United States, for four weeks in April, as stated by the *Sanitarian*, shows a minimum (Toledo) of 11.04, and a maximum (Paterson) of 30.63. The rate in New York was 28.70, Philadelphia 24.42, St. Louis 12.65, Chicago 19.11, Boston 20.31, Baltimore 17.53, Cincinnati 15.15, New Orleans 21.09, San Francisco 17.71, Pittsburg 19.22, Charleston 27.82.

THE Peabody Museum of Archæology and Ethnology at Cambridge, Massachusetts, as we learn from the *American Naturalist*, lately received from Mr. A. Agassiz a fine collection of objects illustrating the archæology and ethnology of Peru. The collection includes a large number of vases, several mummies, and trinkets, utensils, etc., from burial-grounds; also a number of human crania from the burial-towers near Lake Titicaca.

SIR WILLIAM E. LOGAN, the geologist, recently deceased, was a native of Montreal, born in 1798. He received his early education in Edinburgh. His first geological researches were made in the coal-fields of South Wales. In 1841 he returned to Canada, and two years later was appointed chief of the geological survey of the provinces. He held this position till 1869, when age and infirmity compelled him to resign. "He has done," says Prof. Geikie, "a great work in his time, and has left a name and an example to be cherished among the honored possessions of geology."

L. L. Stowell